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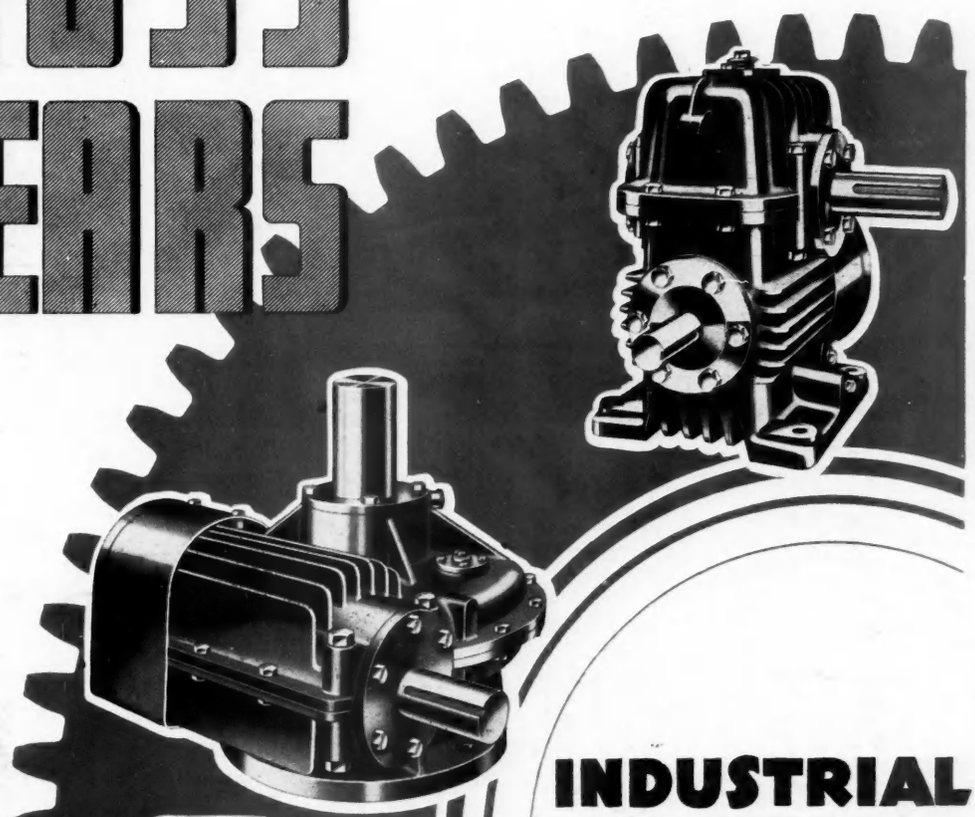

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The Engineer

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A Seven-Day Journal

A Ministry of Supply Exhibition

UNDER the title of "A Great Achievement," the Senior Economy Officer of the Ministry of Supply, Sir Vyvyan Board, has arranged an interesting, if small, exhibition, which is designed to illustrate the increased production of munitions of war, combined with savings of raw materials and the uses of new materials. It opened on Monday last, August 9th, and will remain open until Saturday, August 14th, between 11.30 a.m. and 6.30 p.m., at the Old Hall of the Royal Horticultural Society, Vincent Square, London, S.W.1. The reduction in the import of raw materials is shown. In the case of paper and its constituent products, it has fallen from 82 per cent. before the war to 24 per cent., while home-produced products have risen from 18 per cent. to 76 per cent. The use of concrete and sawdust-concrete blocks in building construction is illustrated. Considerable savings in wood have been effected by a standardised cotton reel and the use of paper lapping boards for textile fabrics. The use of fabric sheets instead of light alloy sheets for parts of aircraft, such as landing wheel fairings and jettisonable petrol pipe connections, is illustrated, a practice which often saves up to 99 per cent. of the metal previously employed. Other exhibits show the improvements made in the manufacture of armour-piercing shells by electric forging methods, and the latest methods adopted for the series manufacture of rifle barrels and bayonets. Two models of the Thompson submachine gun and the Sten gun clearly illustrate the great reduction in metal and weight and in man-hours which has been achieved. Improved methods of packing these guns for transport are shown. The increasing use of plastic materials is emphasised, and the saving in materials which results from the reconditioning of Army clothing and boots is made clear. Various methods of gauging machined and pressed parts, such as cartridge cases and shells, are demonstrated, including the newly developed high-pressure air gauges, with dial recorders, which are now designed by the N.P.L. for making four simultaneous measurements, and "Hysil" glass gauges. In the manufacture of field and anti-aircraft and anti-tank guns we noted that improved design and new materials have achieved considerable saving in weight and in man-hours. An example shown is the recuperator block for a 25-pounder gun, which is now made from tubes and welded sections and is some 900 lb. lighter than the old type forging. The use of cold-rolled steel trusses and purlins in modern roof construction is also shown.

Fuel and the Gas Industry

LAST week a meeting took place between the Fuel Efficiency Committee of the Ministry of Fuel and Power and the Co-ordinating Committee of the Gas Engineering Advisory Board, at which it was announced that the gas industry had set itself the task of saving an additional 200,000 tons of coal in the next year. This amount, it is pointed out, is a larger percentage of the total fuel used at gasworks than it would at first appear to be. Of every 100 tons of coal dealt with by a gasworks, the equivalent of about 75 tons passes out to the consumer in the form of gas or coke. Thus the whole of the economy must be achieved by savings made in the 25 tons which remain out of the 100 tons treated. The economy target of 200,000 tons represents about 4 per cent. of the total coal carbonised. In order to improve efficiency and to render further savings possible, the Regional Gas Advisory Boards are setting up a scheme for mutual help. This idea originated in Birmingham, where the engineers at one of the larger undertakings adopted some of the smaller gasworks in the vicinity. They made regular visits and were able to give technical advice and on occasion to lend equipment and in some instances labour. Where chemical laboratory facilities were unobtainable a travelling laboratory was fitted up in a caravan body and was staffed with the necessary assistants. Without these arrangements it is possible that the supplies of gas to munition works in the area might have been interrupted on many occasions. This organisation is now being extended to other parts of the country and adapted for the economy campaign. Estimates have been prepared for each undertaking showing the quantity of coal necessary to make the works quota into gas and coke, and it is the object of each works to reduce this quantity as much as possible. Already good reports are being received from works, following the pooling of technical advice. Through the Industrial Gas Centres which have been established, it has been possible to provide for the services of gas engineers in order to deal with gas-fired furnace problems and other gas-fired equipment. At the meeting referred to Dr. Grumell, the Chairman of the Fuel Efficiency Committee, thanked Mr. E. V. Evans and the Co-ordinating Committee of the Gas Engineering Advisory Board for arranging the meeting. He said that the coal position was serious, but he felt that by this plan the gas industry would achieve further substantial fuel savings.

Salving the U.S.S. "Lafayette"

ON Sunday, August 8th, a further stage was reached in the salving of the sunken hull of the U.S.S. "Lafayette," formerly the French Line flagship "Normandie," which, on February 10th, 1942, heeled over and lay on her side, with her stern in contact with the end of Pier 88, her hull in a diagonal position across her berth, and her bow resting on a ledge of rock. During the last few months upwards of 5000 tons of superstructure have been removed from the ship, and another 6000 tons from the interior in order to facilitate righting operations. It was also necessary to blank off about 356 portholes, many of them deeply sunk in mud, and to divide the hull into nineteen water-tight compartments, in which over ninety pumps were installed. By means of carefully planned pumping operations it has been possible to reduce, gradually, the amount of list. On Sunday, according to a correspondent of *The Times*, the whole of the main deck was brought above the waters of the Hudson River, and by the middle of the afternoon, at high water, the original list of the ship of about 79 deg. had already been reduced to little more than 49 deg. On Monday further progress was made and the list was reduced to about 46 deg. The original plan was to right the hull to 45 deg. and then to tow it to some other part of the Hudson River; but if all continues to go well, it seems possible that the ship may be refloated and turned in her own berth. The director in charge of the work is Captain B. F. Manseau, U.S.N., and many divers have been constantly employed under difficult and dangerous conditions. The hope is expressed that the hull will be ready for refitting as a troop-carrier, to be begun in about two months' time. Up to date the cost of salvage operations is given by the Navy Department as more than £750,000. Almost exactly a year ago, in our issue of August 14th, 1942, we gave a full account of the work done up to that period, with some excellent U.S. Navy photographs as a Special Supplement. We hope, in the not-distant future, to publish a full description of the later stages of this interesting salvage operation.

Canadian-Built "Mosquitoes" Fly the Atlantic Ocean

IT is announced by the Ministry of Aircraft Production that on Monday, August 9th, a flight of "Mosquitoes" built in the Canadian De Havilland factory, arrived on a British airfield after a successful Atlantic flight. The machines were flown from Canada by the R.C.A.F. and by civilian crews of the R.A.F. Transport Command. In our issue of May 7th we gave an illustrated description of the design and manufacture of this interesting bomber and fighter aircraft of wooden construction. Mention was made of the fact that the Canadian De Havilland factory was turning out "Mosquitoes" in large numbers, and that these machines were being equipped with American-built Rolls-Royce "Merlin" engines, constructed at the Packard Company's American factory, and with De Havilland constant-speed full-feathering propellers of the type manufactured by the Hamilton Company of America. It may be recalled that the first Canadian "Mosquito" took the air in Toronto late in 1942, just a year after the arrival in Canada of two senior engineers of the De Havilland Company, who inaugurated the Canadian factory. It can now be revealed that more than 8000 drawings followed the engineers across the Atlantic, and that more than 98 per cent. of these drawings arrived safely at their destination. They were followed by jigs, sample parts, and units, and other supplies as the factory grew. The trans-atlantic flight follows other remarkable performances of "Mosquito" aircraft, which in July last year flew to Russia and back in a day, while another machine flew to Malta by way of France and Italy. A feature of this remarkable design of aircraft is its high speed. The "Mosquito" bomber can fly faster than enemy fighters.

Axis Shipping Losses

ACCORDING to an official statement issued by the Admiralty on Monday, August 9th, during the forty-six months of war up to June 30th, 1943, a total of 9,045,683 gross tons of German and Italian shipping was captured, sunk, or damaged by surface ships, submarines, aircraft, or mines. These figures, it is stated, are exclusive of the losses which have been inflicted upon Japanese shipping. They do not include successes by our Russian Allies in the fight against the common enemy nor the amount of tonnage which is immobilised by our blockade in the ports of those countries which are not at war with Germany. During the year which ended June 30th, 1943, the total of German and Italian merchant shipping which was captured, sunk, or damaged increased by more than 2,867,000 gross tons.

Machinery in Coal Mines

IN a Journal note of July 30th we recorded a letter from Mr. Austin Hopkinson to the editor of *The Times*, expressing the view that in Great Britain we had perhaps "over-mechanised" our collieries. Writing on this same subject of machinery in coal mines in a letter published in *The Times* of August 11th, Sir Richard Redmayne states that, in respect of surface equipment and underground haulage, our mines are as fully furnished with machinery as those of any other country and that in underground economic "lay-out" our collieries are surpassed by none in any foreign country. In reply to the criticism that the mechanisation in British mines is inadequate, Sir Richard points out that a knowledge of working conditions is essential in comparing British and foreign mining practice. There is no doubt, he says, that where a mechanical coal cutter can be worked in connection with a mechanical face conveyor, or a mechanical loader, the ideal is reached in respect of both. But, he says, it must be borne in mind that the economic use of these mechanical means of getting coal is determined by certain governing conditions. Thus, where the roof is so tender—a condition which obtains at a number of British collieries—that it is necessary to keep the timber supports close to the face, it is impossible to use a mechanical coal cutting machine, and where the coal is friable or where it is characterised by cleavage in the form of "backs" or "joints" from which the coal is likely to break away and bury the machine, as in the case of many collieries in the great South Wales coalfield, machine mining is rendered difficult, if not impossible. In the coalfields of the United States of America, of Germany, Poland, and the Netherlands, the natural conditions are far better suited to the application of mechanical undercutting than in some parts of our British coalfields. There are, too, other factors apart from mechanisation which enter into consideration when comparing output per man shift at British collieries with those at foreign collieries—to mention only two—thickness of seam worked and the length of shift worked.

Engineers and the British Empire

By Professor MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

No. VI—(*Continued from page 104, August 6th*)

The Canadian Pacific Railway

CANADIANS have always been rightly proud of the fact that this great railway was finished when there were only 5,000,000 people in the country. They knew it had been a great risk to undertake the work, but they had realised its urgency, even although they had summed up the cost of laying a line around the head of the Great Lakes and over high mountains, as well as the gamble concerning the profits that might be obtained from the wide expanse of lonely prairie. The entry to, and the crossing of, British Columbia was a prodigious task. There were the Rockies with an average width of 60 miles and peaks up to 19,539ft. From the Rockies on to Vancouver there were other mountain ranges—the Purcells, the Selkirks (80 miles wide), the Gold Range (60 miles wide), and the Coast Range (100 miles wide). The coast mountains caused the engineers anxiety, because they fall so rapidly to the sea. A little group of daring men carried the work of survey and construction to success in half the time estimated. And so the C.P.R. furnished a new and a great world route from Europe to Asia. Perhaps its most remarkable feature is the directness with which it approaches the final destination in the west.

When they heard of it, the British public were stirred by the magnitude of the project and its possibilities from an "Empire" point of view. They contributed to its capital funds and aided the development of the company's services on land and sea. I have travelled on the railway and on luxurious "Empress" vessels from Hong Kong to Vancouver and from Montreal to England. Although I have travelled by rail across Asia, Europe, and the United States, and have made many voyages across the Atlantic, the Pacific, and other seas, I have never been more comfortable, nor carried more quickly over a long route, than by the C.P.R. services.

It may be of interest to note that shareholders in the United Kingdom and other British countries, excluding Canada, owned (1939) 65·47 per cent. of the capital of the company's preferred and common stocks, so that it is evident that the British people had an economic as well as an "Empire" interest in the future of Canada.

The prospect of increasing trade with China and Japan, *viâ* the Pacific, was a factor in creating the urge to build this railway. Since the days of Marco Polo there has always been present in the minds of British adventurers the lure of Cathay, with its curious products, such as tea, porcelain, raw silk, and its reputed wealth, strange inhabitants, &c., a land of mystery and rich prizes. In 1610 Henry Hudson made his last tragic voyage in search of the North-West Passage to the Far East, and was cast adrift by mutineers, to die in the bay in Canada that bears his name. His fate resulted in a British expedition with a patent covering "all the seas between Hudson and Davis Straits and northward, north-westward, and westward to Tartary, China, Japan, Korea, and to all other countries in the South Sea in America, Asia, and the islands."

The lure of Cathay, many years later (1807), caused that great pioneer in Canada, Mackenzie, to make strenuous efforts to persuade the British Government, the East India Company, and the City of London magnates to build, through Canada, an overland chain of forts, with waterways to connect them, so that British trade would become paramount on the Atlantic and Pacific. The intrepid Scot failed, but he had useful surveys made in western Canada.

The Empire Route

The dream of the all-red route from Britain *viâ* Canada to China never faded, but it was the indomitable supporters of the C.P.R. that made it possible for passengers and freight to cross the two oceans and a continent under the auspices of one British company.

In his fascinating story of the C.P.R., which he calls "The North-west Passage of To-day," J. M. Murray* reminds us of the gold rush to British Columbia (1858), when 30,000 people arrived at Victoria in a few weeks, with the Chinese swarming in to earn a living in however humble a capacity. These "pidgin-English" residents submitted an address to the British Governor, which reads: "Us like this no charge place; see it grow and grow higher to highest; can see a Canton will be in Victoria of this Pacific. The Maritime enterprises will add up wonderfully and come quick. China has silks, tea, rice, and sugar. Here is lumber, coal, minerals and fish—an exhaustless supply which no other land can surpass." With their genius for trade and their curious foresight for profit, the Chinese realised the tremendous possibilities of development in Canada, even when some statesmen in Britain were talking of "cutting the painter" with our Colonial Empire.

Beyond all else, however, it was the determination of the leaders of the 3½ million Canadians of 1871 to remain in the British Empire that made them determined to build the C.P.R. The purchase of Alaska (1867) by the U.S.A. and the fear that British Columbia would follow Alaska, made the Government of the Dominion undertake to build the railway (1870). A general survey that employed 800 men in twenty-one divisions was organised. Various routes were explored; at one time the survey maps made the planners favour one running over the Yellowhead Pass. The chief engineer, Sandford Fleming, stated, after he had studied the surveys, that any one of the several routes mapped out would make the journey from Britain to China 1000 miles shorter than by rail across the United States.

The Coast Range, a "stupendous snowy barrier, thinly wooded, and rising abruptly from the sea to the clouds"—Vancouver's description (1792)—has a mountain 13,260ft. high and surrounding peaks of 11,000ft. and more.

The first sod was turned on the main line in June, 1875. Telegraph lines were built. A stern-wheeler and a locomotive arrived at Winnipeg (1877); the contractor, named Whitehead, who imported it, built a branch of the railway. He had been a fireman on the first passenger train in Britain over the Stockton and Darlington Railway.

Engineers, statesmen, and financiers were hampered by the personal and political quarrels that endangered success. Military considerations of defence had to be weighed, for Russia was then feared in England and Canada. There was an outcry when Chinese labour was imported to replace, in British Columbia, the white clerks out of employment, broken-down bar-tenders, and other almost useless failures, from San Francisco, men who had never handled a shovel before; but on the prairies the work went on at a great speed. Calgary, Winnipeg, and other large towns now on the map were then just a collection of a few log houses.

Amongst other benefits the C.P.R. conferred on Canada was the accidental exposure of the mineral ore at Sudbury, which was the

C.P.R. Bridge in Saskatchewan

* "Steel of Empire," Rich and Cowan, Ltd., London.

beginning of the giant plant created by the International Nickel Company. A worker on construction became curious when he saw the colour of material he unearthed. Soon afterwards the Dominion authorities sold the land, rich in mineral wealth, at a dollar an acre!

Out in the farther west the engineer contractor, Onderdonk, was building the track through mountains with perpendicular faces hundreds of feet high, crossing the deep gorges, spanning rushing cataracts. On 60 miles of construction he had 7000 men at work, blasting millions of tons of rock, which fell into the Fraser River; boring fifteen tunnels (one of them 1600ft. long); suspending workmen by ropes for hundreds of feet down the vertical sides of mountains, and using mules, horses, and canoes to carry materials over the Indian trails.

Then, in September, 1885, Onderdonk's great work of construction in British Columbia was finished, and the last spike on this "Steel of Empire" was driven home by Lord Strathcona on the Eagle Pass, discovered two decades earlier by an engineer named Moberly. No golden nor silver spike was held in position by Major Rogers, an engineer with a fine record for construction on the line—the spike was just plain iron. Sandford Fleming records that "the engineers, the workmen, everyone present, appeared deeply impressed by what was taking place. It was felt by all to be a moment of triumph." There was a tremendous cheer from men who knew well the dangers and hardships they and their friends, many of whom had lost their lives, had endured. There were no speeches; the indomitable planner, Van Horne, merely remarked: "All I can say is that the work has been well done in every way." The conductor of the train shouted: "All aboard for the Pacific," and so, with renewed cheering, the train went over the rails and went on to the ocean terminus due west.

The C.P.R. and the C.N.R. have numerous branch lines, some absorbed from earlier companies. Both concerns have passed through periods of crisis. Many improvements have been made on both systems since the original construction. The C.P.R. directors have, for example, built new tunnels, provided palatial hotel accommodation at many places for tourists, and generally made traffic conditions easier.

When the railway was first built, the line at the "Big Hill," near the "Kicking Horse Pass," had a gradient of 3·3 per cent., rising 232ft. per mile. It often happened that as one engine could not manage the haul, three or four were needed to pull and push the train at a crawling speed. This caused much delay. On a 0·4 per cent. gradient a 190-ton locomotive was able to haul 3768 tons, but on a 1 per cent. gradient it could only haul 1780 tons.

Nowadays, as the train comes west from Calgary it enters a spiral tunnel, 3200ft. long, under the Cathedral Mountain. It turns a complete circle, and, passing under itself, comes out into daylight. Then it turns to the east, crosses the Kicking Horse River, and enters a second spiral tunnel, 2910ft. long, under Mount Ogden. Again it turns a complete circle, passes under itself once more, comes out into daylight, and crosses the river for the third time.

Across the Selkirk range the line avoids a climb over Roger's Pass. A 5-mile double-track tunnel was built to penetrate Mount Macdonald. Not only does this very long tunnel prevent any danger due to snow-slides; it shortens the route over the Selkirks by 4¼ miles.

Some very interesting contributions to THE ENGINEER have been made by Mr. Edward H. Livesay, entitled "Canadian Locomotive Experiences," and it is therefore unnecessary to say very much about the details of modern transport over the long transcontinental run. He has given particulars of recent locomotives and the route. Especially interesting is the following description of the famous Fraser Canyon: "At Yale the Fraser Canyon begins, and we are well into the wilderness of rock and torrent. Towering cliffs rise straight on from the river, the two railways, C.P. and C.N., and the motor road leading to the Cariboo highway, fitting in as best they can. The gradients are fairly heavy, and the profile saw-tooth, the speed seldom rising much over 40 along here. Stops are frequent, the conductor signalling to the engineer by means of an air whistle in the cab; three blasts mean 'Stop next station,' for instance. The engineer answers with the engine whistle. Past Hell's Gate, where the canyon is only a few hundred feet wide and the mountains drop some 2000ft. almost sheer into the tossing, snow-fed waters, yellow-white, and boiling through the narrow gap; on the other side the C.N.R. and the motor road—its forerunner buried under the railway embankment—forced to find a precarious footing high up on the mountain side; into North Bend, O.T. at 2.25 p.m., after about fifteen stops, 129 miles in 265 min., an average of 29 m.p.h."

These articles give a very vivid account of the wonderful route and technical details concerning the locomotives and rolling stock in use. They show that the enterprise of the pioneers who planned and built the line is still maintained by those now responsible for it. They created in my mind a great desire to see, once again, the wonderful scenery and the triumph of engineering construction in British Columbia. It is a trip which will delight any reader who can manage to undertake it.

THE ENGINEERS RESPONSIBLE FOR THE WORK

For fifteen years, after the C.P.R. transcontinental line was commenced, numerous, and now forgotten, surveyors and engineers endured much suffering and misery; many a brave man lost his life. Only a few names are recorded.

Sir (then Mr.) Sandford Fleming was chief engineer of the original Government surveys, and he planned this great engineering work. Sir John Macdonald conceived it, but the great work was Fleming's monument. An engineer, J. H. Secretan, worked under Fleming's direction on survey and construction details for ten years, and later worked under Van Horne. He described* his chief (Fleming) as follows:—"He was a Scotchman of the finest type, rugged as a block of granite, determined, and sometimes obstinate, but of a kindly disposition to his subordinates, and first, last, and always a *gentleman*. The task imposed on him as pathfinder for this tremendous transcontinental trail would have overawed most men, but it did not daunt Sir Sandford. He quickly surrounded himself with a large staff, efficient and otherwise, and proceeded to organise original surveys."

Two district engineers, Marcus Smith, M. Inst. C.E., and J. H. Rowan, C.E., were placed in charge of the western (British Columbia) and eastern districts of the suggested route respectively.

VIADUCT ON C.P.R. MAIN ROUTE

* "Canada's Great Highway" (John Lane, The Bodley Head, Ltd.).

Walter Moberly, famous as the discoverer of the Eagle Pass, was a very capable engineer. He planned a good route over mountains, where he was handicapped by fallen timber, heavy undergrowth, and vicious weeds. An experienced railway engineer, McLennan, planned the route to cross the Yellowhead Pass. Marcus Smith suggested routes even farther north, and Sandford Fleming considered one as far north as the Peace River.

H. J. Cambie supervised the work on the very difficult section of the Fraser Canyon. He records that many of the men on construction work were highly educated Englishmen, who had drifted through most parts of the world, but were good workmen.

Major Rogers, capable pathfinder, was famous for his picturesque profanity, his overalls with a plug of tobacco—he chewed continuously—in one pocket and a sea biscuit in the other—all the provisions, in his opinion, needed by an engineer.

Secretan relates tales of hardship, days without food, pests of mosquitoes, biting cold, and gives some amusing anecdotes in his book. He pays a tribute to the splendid conduct of the divisional engineers and all their officers and men engaged on the surveys. He did a great deal of the pioneer surveying and construction work.

H. S. Holt (afterwards Sir Herbert) was chief engineer for James Ross, in charge of construction in the Rockies. Holt was a young Irishman who, at the age of twenty-six, came to Canada with no money, but about sixty years later was said to have become "Canada's most powerful and richest citizen."

C. C. Schneider, who later was President of the American Society of Civil Engineers, designed many of the bridges. In building both transcontinental railways, engineers who had experience on rail construction in the United States did excellent work.

It is impossible to mention all of the engineers, managers, and financiers, but many names are to be found in the records in Canada concerning the construction of the railways. They show that there was brilliant strategy revealed by the enthusiastic supporters of the Empire route. Considerable ingenuity to gain control was shown by experienced railway operators from the States, but they failed. There was much squabbling by rival politicians, yet in the crises always strong support, including valuable grants of money and lands, was given by various Dominion Governments.

Thus it happened that the old dream of the early navigators who sought a westward path to far Cathay from Europe was made a reality, centuries later, when mechanised power was able to enable men to travel more swiftly, more safely, and with far greater comfort than the pioneers in the sailing ships had imagined in their wildest thoughts concerning progress and trade.

In spite of the depression in the 1930s, the railway and the steamships were efficiently equipped and thoroughly up to date when last I travelled on them in 1935. There was no lowering of the standard of the 21,275 miles of road bed, and the coaches and freight cars seemed to be well in advance of present day requirements. For more than sixty years the railway has operated and it is a record of which the British Empire can be justly proud.

The C.P.R. and C.N.R. have placed many thousands of settlers on the farm lands of the western prairie, but Canada still needs a greater population, and there can be no doubt that as time goes on the traffic on these lines will greatly increase. It must be obvious that the demands made upon Canada during the global war must have immensely increased the value of these railways to the Empire. When the story of the terrific effort which has been made in the Dominion in our cause comes to be written, the debt which we owe to these two great railway systems in Canada will no doubt be revealed.

Road Transport Facilities

Canadians quickly took advantage of the opportunities to use mechanised vehicles on roads and farms. An officer of the celebrated "Mounties" travelled with me for two days and two nights on the C.P.R. He told me that very few members of that force nowadays ride horses, for they use motor-cars. Canada manufactures all types of motor vehicles, many of which were exported to other parts of the Empire.

My nephew in Calgary motored me some thousands of miles in the Western Provinces and up to the north well beyond Edmonton. There were rest camps, with log huts containing fuel and water, where we stayed for a dollar a night, providing our own food, &c. He mentioned, quite casually, that during the previous summer, he and his family had packed everything possible into their car and had motored down to Los Angeles for their holiday. It was, I suppose, a 3000-mile jaunt, but they are used to long distances in North America.

It is possible to motor right across Canada, except for a short distance where the car must be shipped over a stretch of Lake Superior. The country which interrupts the road makes construction work too costly to be worth while.

The now-famous Alcan road runs from the terminus of the Alberta Northern Railway, Dawson Creek (495 miles from Edmonton), on to Fairbanks in Alaska. Road construction covered about 1800 miles over very difficult country. It was planned, surveyed, built, and financed by the U.S.A. Government. The Corps of Engineers of the U.S.A. Army did the construction work, aided by American and Canadian contractors. The detailed story of the great highway is recorded in THE ENGINEER for March 12th and 19th, and June 18th and 25th, 1943.

It was a war measure, but it must prove of immense value to Canada, especially in the development of the province of Alberta, and the Yukon and N.W. Territories. It must inevitably increase the importance and the population of Edmonton.

Air Lines in Canada

The long distances and the difficult terrain in Canada ensures that the air will be a great highway in the future. It has already opened up the frozen north. Montreal and Vancouver—2785 miles apart—are only a day's journey distant by aeroplane. The Canadian Minister of Transport said of air travel, "another nail has been struck in the coffin of sectionalism, and a new advance made in the growth of Canadian nationalism." The Government owns the Trans-Canada Air Lines Corporation, which operates most of the routes and which is a subsidiary of the C.N.R.

The round-the-world route by air is the Transatlantic Line, the Trans-Canada Airway, the northern route to Asia; the Imperial Airways operated from Hong Kong to Britain.

For ten years after 1918 the development of Canadian aviation was concentrated on the vast territory stretching up to the snows of the Arctic. For it was only by air travel that it was possible to map, explore, and exploit the mining and the transport of the gold and radium which had been discovered in the Far North.

That frozen waste has now yielded up to humanity some of its age-old hidden treasures. Even when the temperature in winter at Aklivik is 50 deg. Fah. below zero, equipment and supplies from Edmonton are dropped from the skies. And so to-day any part of Northern Canada can be safely reached with ease.

Canada is interested in extending an air service to the Far East. Pan-American Airways ran a frequent service from San Francisco to Hong Kong *viâ* Honolulu and Manila, but the shorter route is *viâ* N.W. Canada and Alaska across the Behring Strait.

If we look at a map of the world, with the North Pole in the centre of the map, we find that our ideas of geography must be revised by air transport, concerning distances between various cities, for the machines can, as we say, go "as the crow flies." Thus, by air, London and Shanghai are almost equidistant from Honolulu. On the air map Cape Town and Auckland are about 50 per cent. further apart than Auckland and Calcutta. Wendell Wilkie returned to the U.S.A. from Chungking, China, by way of Alaska and Edmonton. The sea route from San Francisco to Liverpool is 8000 miles; the air route, which crosses Canada, is 5200 miles. Berlin can be reached by air from Edmonton in a shorter time than Tokyo.

The saving in time is striking, for a cargo aeroplane can make twenty-five trips while a cargo ship is making one. The speed of the famous Pacific "Empress" liners was high in order to save days of bank interest and insurance on silk from the Far East. The cargo aeroplanes will reduce these charges very considerably.

The world seems not only to have shrunk, but to have changed its shape. Edmonton, a city carefully planned to accommodate a population as great as Chicago, was, when I visited it in 1935, covered with buildings over scattered areas, with "wide, open spaces" in between, so that only about 30 per cent. of the land area in the city was built over. It has now found itself in a pivotal position for important air routes, and is also the terminus of the great Alcan road to Alaska.

The King's mail is now carried by air to out-of-the-way parts of Canada that were formerly very isolated. Aklivik, on the Arctic Ocean, was almost unapproachable during the long winter season—a dog-team service operated only twice during the severe climatic conditions of the winter. It now obtains air letters regularly from Edmonton. Whitehorse, in the Yukon, had to depend for mail on steamer and dog team. It is now one day's flight from Vancouver. Remote settlements in other parts of the Dominion, formerly entirely isolated, now obtain a regular air mail service and receive news of the world by wireless. The Canadian Broadcasting system is modelled on that of the B.B.C., with a compromise method of finance. It is impossible to compete with wealthy chains of the U.S.A., with licence revenue only, so time is sold. The C.B.C. has its chain of 50,000-watt stations.

The air services, rapid delivery of letters, cables, and wireless, play an important part in promoting the unity of the Empire. The forging of those links by engineers gives us a justifiable pride in our work as Empire builders.

(To be continued)

Asbestos Control.—The control of raw asbestos is now exercised by Mr. C. J. Brockbank, who is already in control of abrasives and graphite in the Ministry of Supply. All communications relating to supplies of raw asbestos should be addressed to the Abrasives, Graphite, and Asbestos Control, Palace Chambers, Bridge Street, London, S.W.1.

Links in the History of the Locomotive

By E. A. FORWARD

No. I

S. AND D. RAILWAY—THE "EXPERIMENT," 1827–28

FOLLOWING the four engines of the "Locomotion" class, described in THE ENGINEER, October 10th and 17th, 1941, the next locomotive built in the Stephenson works was that bearing the works number 8; it was afterwards sold to the Stockton and Darlington Railway and named "Experiment." This engine was a remarkable departure from the previous designs and was the first Stephenson locomotive to embody horizontal cylinders. We do not know who was responsible for its design; it may have been George Stephenson, but it cannot have been Robert, who was still abroad.

For many years all that was known about it was contained in John W. Hackworth's statement that it had a single flue and two horizontal cylinders, partly inside the boiler at the fireplace end, the pistons driving one pair of wheels through the medium of countershafts and levers and sloping connecting-rods.

Even this statement was not generally known, and W. W. Tomlinson, when writing his "History of the North-Eastern Railway," was not aware of this feature of the engine, although he had found, in the Stockton and Darlington Company's records, correspondence relating to it which dealt entirely with its other remarkable feature, the water-tube grate, which was not mentioned by John Hackworth.

In a letter to THE ENGINEER in 1879, Mr. George Graham gave a description similar to that of John Hackworth, but stated that the engine had a return flue, which it could not possibly have had until after it was rebuilt in 1830, with vertical outside cylinders.

The discovery of the Prussian engineers' report, however, in 1922, revealed its true form, as they saw it under construction, at Newcastle, early in 1827, and they gave a fairly complete description of it, noting both its horizontal cylinders and the water-tube grate.

This account proved that the engine was actually in an advanced state of construction about April, 1827, thus effectually disproving J. W. Hackworth's specious tale, quoted by Robert Young, to the effect that the construction was hurriedly carried out only after the "Royal George" was undergoing trials, about November, 1827. We now know, moreover, that it was actually sent to Darlington for trial before the "Royal George" was put to regular work.

The Prussians' description contained some doubtful points, but part of these were satisfactorily settled by the Rastrick notebook of January, 1829, which contained a sketch of the engine after it had been placed on six wheels, but still retained its horizontal cylinders. Notwithstanding this information, it was not yet clear when this engine actually appeared on the railway.

The correspondence found by Tomlinson in the "N.E.R. Muniments" was between S. and D. Railway officials and Messrs. R. Stephenson and Co. He does not give it in full, but makes quotations which would have had greater technical value if he had been an engineer.

Tomlinson says that while the "Royal George" was being built at Shildon the railway company was in treaty with Messrs. Stephenson for the purchase of a new locomotive which that firm had just completed. The special feature of the design was the use of small water tubes for effecting more rapid evaporation of steam. An inquiry from the railway company drew from Mr. Harris Dickinson, the manager of the Newcastle works, the following letter of explanation, addressed to Edward Pease and dated October 24th, 1827:—

"In answer to thy favour of the 20th inst., respecting our new locomotive engine, we are of opinion that there is little or no more risk attending this engine than the former ones, and the only danger I apprehend is from the bars burning away, and so blowing out the hot water and scalding those who may be employed at the engine, but how can these hollow tubes burn away so long as they are filled with water? and if, from any neglect, the communication between the boiler and the fire tubes should be stopped, so that the tubes burned into holes, there could not then be any water to blow up."

By a Sub-Committee Minute of November 9th, 1827, T. Hackworth was instructed to write to R. Stephenson and Co., declining a trial of their new engine unless they were satisfied that its weight without water was below 7 tons, while a later Minute of November 16th recorded that "Stephenson and Co. have guaranteed their new locomotive engine not to exceed the weight of 6 tons 15 cwt. It is therefore on its way to Darlington for trial."

Hackworth's notebook, under date November 17th, 1827, states: "T. H. at Darlington got No. 5 locomotive taken off the carriage and set upon the line in 2 hours ¾," and there can be little doubt but that this was the arrival of Stephenson's engine No. 8. For some reason Hackworth calls it No. 5, although it is possible that an 8 has been misread as a 5 in the notebook.

Tomlinson continues: "The result of the trial was to show that the fireplace would have to be altered. The reason for this can only be conjectured. Probably on account of the small water tubes it was found necessary to lower the grate, and this could only be done by adding a fire-box. Hackworth was afraid that if the fire-place alone was altered too great a proportion of the weight would be thrown on the two hind wheels. Stephenson's manager, in a letter to Edward Pease, dated November 26th, 1827, suggested that the experiment should be tried, and if any bad effects from the disproportionate weights should occur, he proposed to bring the engine back to Newcastle and fit it up with six wheels, which, he considered, would be an entire remedy."

Tomlinson had found evidence in the S. and D. records that an engine was sold to the company in February, 1828, costing, with tender, £550, which he takes to be the one referred to in the correspondence, but he goes on, mistakenly, to call it the "Rocket," an engine not delivered until September, 1829.

Warren, also, owing to a difference between the guaranteed weight and the weight given by Hackworth, in January, 1828, for the "Experiment," which he then called the "Quadrant" or "Lever" engine, rejected the notion that the engine sent for trial in November, 1827, was the "Experiment," and supposed it to be some other unrecorded engine or possibly one of the engines ordered by Marc Seguin for the St. Etienne-Lyons Railway.

The Stephenson ledger now sets these doubts at rest and definitely proves that this horizontal cylinder engine with water-tube grate, seen by the Prussians early in 1827, was actually the engine sent for trial to the S. and D. Railway in November, 1827.

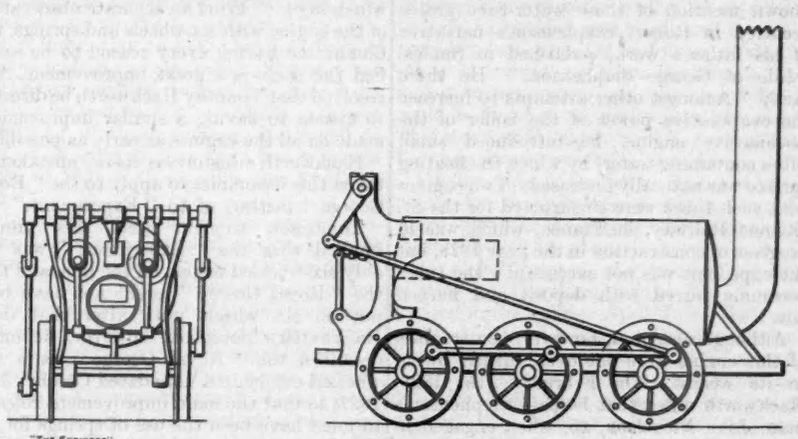

FIG. 1—THE "EXPERIMENT," 1828 (RASTRICK)

The first ledger entry relating to "Travelling engine No. 8" notes the supply of castings from the foundry during the quarter ended June 30th, 1826, while more castings, making a total of more than 75 cwt., were supplied by December, 1827. The engine had therefore been on the stocks for over nine months when the Prussians saw it, and 11 cwt. of castings were worked into it after the date of their visit. We have also, amongst the incidental expenses for November, 1827, "Tolls on No. 8 Travelling engine, 11/–," completing the tale of its despatch from the works, although, as it was only sent on trial, it was not, at that time, invoiced out in the ledger amongst the goods sold.

From Hackworth's notes, and further Sub-Committee Minutes, it is evident that the engine gave trouble from the first. Alterations were made to it at Shildon during December, 1827, and January, 1828, but it appears to have been brought to a satisfactory working state by January 30th, 1828, when Hackworth recorded its weight as being 7·39 tons, light, as compared with the earlier guaranteed weight of 6·75 tons. As Hackworth gave the weight of the fire-door, grate,

bearers, and bridge separately, it is evident that the water tubes had then been removed and were to be replaced by an ordinary grate.

That the engine was then accepted by the railway company is shown by a ledger entry of February 4th, 1828, where it is booked out as "1 Locomotive engine and tender complete, £550." It was paid for on March 18th by a three months' bill for £550, falling due on May 13th, 1828. Hackworth partisans have been fond of decrying anything made by Messrs. Stephenson and Co., but the fact that the railway company purchased the "Experiment" after the tubular grate had been removed, presumably on the recommendation of Hackworth himself, showed that, apart from its weight, it was considered to be a good engine.

The ledger shows that the only other locomotive engines under construction at that time were Nos. 9 and 10 for the St. Etienne Railway, which were delivered in March and April, 1828, and No. 11, afterwards "Lancashire Witch," delivered on July 1st, 1828. Castings for No. 9 are first noted in the quarter ended September 30th, 1827, and for the others in the quarter October-December, 1827.

It may be pointed out here that the first known mention of these water-tube grates occurred in Robert Stephenson's narrative of his father's work, published in Smiles' "Life of George Stephenson." He there said: "Amongst other attempts to increase the evaporative power of the boiler of the Locomotive engine, he introduced small tubes containing water, by which the heating surface was naturally increased. Two engines with such tubes were constructed for the St. Etienne Railway, in France, which was in progress of construction in the year 1828, but the expedient was not successful; the tubes becoming furred with deposit and burned out."

Although accepted, however, the troubles of this engine were not over, mainly owing to its weight. On February 7th, 1828, Hackworth noted that he paid Stephenson's man, John Nicholson, £5, when engaged in altering No. 7 locomotive, viz., the "Quadrant" engine. He here gives the engine its correct railway number, in view of the now known fact that there were five engines of the "Locomotion" class and the "Royal George" already on the line.

On March 26th, 1828, Hackworth was ordered by a Sub-Committee Minute to "lay off the last engine from Newcastle until it be placed on six wheels." On May 2nd Hackworth noted that he "is to write to Mr. Stephenson to ask him what will be cost of altering the locomotive to six wheels, an immediate answer wanted."

On May 14th and 15th he was "at Newcastle giving directions about the 'Quadrant' engine, got the length of the frame to send to Bedlington, springs for same, to be put on six wheels, and metallic pistons." This implies that this engine had not metallic piston packing at first.

In spite of the prohibition, however, Hackworth continued to use the engine, as in May he noted "Send down the 'Quadrant' engine to bring waggons," while on May 15th he notes: "Waggon men drinking, 'Quadrant' engine cylinder bottom failed."

Tomlinson quotes letters from Messrs. R. Stephenson and Co. of May 27th and June 11th, 1828, in which the railway company was assured that "no time would be lost with their travelling engine frame, the makers being busy with the springs, and the frame parts being expected at any time from Bedlington."

On July 4th, 1828, the company, by a Sub-Committee Minute, ordered that "the last locomotive engine purchased by the Company shall be wholly laid aside until the alteration prescribed of placing it on six wheels be carried into effect, its weight being proved to be too great for the strength of the Company's rails."

The ledger, under date July 19th, 1828, records the delivery of "1 frame for locomotive engine fit up on springs complete, £87 12s."

Hackworth, on July 25th, 1828, noted that he "must enquire as to assisting Mr. Stephenson's men with the engine they are altering, we have over few men at any rate considering the work we have before us, is it to be understood that the company pay these workmen sent from Forth Street."

Ledger entries of August 1st and 8th appear to refer to additional parts for this engine, while an entry of September 13th gives particulars of the time and wages of five men when employed in fitting the engine with its new frame. The total cost in wages, lodging allowances, and travelling expenses came to £45 9s. 1d. This shows that the work was completed at the middle of September, 1828, and the satisfactory performance of the engine after the alterations is recorded in a Sub-Committee Minute of October 31st, 1828, which says: "From an accurate observation of the engine with six wheels and springs, the Committee having every reason to be satisfied the same is a great improvement, it is resolved that Timothy Hackworth be directed to attend to having a similar improvement made on all the engines as early as possible."

Hackworth's historians have, mistakenly, taken this encomium to apply to the "Royal George" instead of to "Experiment."

Tomlinson thought that this minute implied that the "Experiment" was the only six-wheeled engine on the line, and that the "Royal George" might not have been put on six wheels until after that date. Hackworth's notebook, however, definitely describes the "Royal George" as a six-wheeled engine in a note dated October 31st, 1827, so that the main improvement referred to must have been the use of springs for the axles, which seems to confirm the theory that the "Royal George" did not have springs until after October, 1828.

There would, moreover, have been little or no advantage in putting the five smaller engines on six wheels, although they might have been improved by spring mounting. This was presumably done gradually, as, according to Pambour's statement, by 1833 most of the S. and D. engines were on six wheels and were mounted on springs.

Spring mounted axles appear to have been first tried on a locomotive on the Heaton Colliery Railway in 1821, while one of the Killingworth engines had them in 1827, as Hackworth was instructed in December of that year to go to Killingworth to see the locomotive with springs and malleable iron rims.

Although placing the "Experiment" on six wheels solved the excess weight difficulty, it was evidently realised that heavier rails would have to be provided, and a start in this direction was made in February, 1828. Hackworth then recorded that the railway company had purchased from the Bedlington Iron Company 325 patent malleable iron railway bars, 15ft. long and weighing 32 lb. per yard, as compared with the 28 lb. of the original rails. The cost of these rails was £332 11s. 2d.

The Stephenson ledger shows that they supplied 1265 chairs for these rails in January, 1828, their weight being 9·75 lb. each and their cost 11s. 1d. per hundredweight.

We come now to the Prussian engineers' description of "Experiment" as they saw it early in 1827.

"Locomotives of Stephenson and Dickinson at Newcastle.

"In the works of Stephenson and Dickinson at Newcastle, there has been built recently (at the beginning of 1827) a locomotive which so far has had no trial on the large scale although it has already been proved in the workshop. In its construction and highly careful execution, it appears to surpass the present practice. Also, regard is being paid to a better use of the fuel. Besides changes in the construction of the fire-grate and the boiler, there is this essential difference that the cylinders lie horizontally entirely in the boiler.

"The boiler is of iron plate with a strong cast iron front plate; it is cylindrical, 13ft. long and 4ft. diameter; in it lies, a few inches above the bottom, a fire tube 2ft. 3in. diameter, wherein at the front end lies the fire grate, and which at the back communicates with a chimney of 20in. diameter and 16ft. high, which, by means of a slide, can be raised 8ft. higher. On the under curvature of the chimney there is a flap which is fastened by cotters and can easily be removed in order to clean the chimney and the fire tube.

"The grate consists of eight hollow wrought iron tubes, 1¼in. inside diameter, ¼in. thick, and 4ft. long. These open at the front end into a box of cast iron in which, on the front surface, there are eight openings, which are closed with screws and serve for cleaning the grate bars. At the back end these grate bars open into a round tube of 20in. diameter, which lies in the fire tube; it is 3½ft. long and reaches as far as underneath the chimney. This latter is in communication with the upper part of the boiler through a rectangular opening which goes through the upper part of the combustion chamber. The boiler itself is in communication with the front iron box through two curved pieces of tube. The grate bars are filled with water and constitute part of the boiler; also the fire tube constitutes an annulus which inside and outside is filled with water.

"The cylinders lie over the fire tube in the boiler and are 9in. diameter by about 2½ft. to 3ft. stroke. They are bolted by their flanges to the cast iron front plate of the boiler. They are united with one another by a cast iron piece through which steam is led to the slide valves and whose opening close under the crown of the boiler is provided with a valve movable from outside in order to regulate the entry of the steam.

"The waste steam flows from the cylinders through an iron tube lying in the boiler towards the chimney, where both these tubes are bent upwards. Before the curved part there leads out a descending tube which opens into a small water tank lying under the chimney. This is used as a feed-water heater, from which the force pump, situated on the side of the boiler, lifts the feed water. In this way part of the exhaust steam is further utilised.

"The piston-rod is fastened to the middle of a short arm whose ends are in connection with the half-beams above and below. On the axis of the upper half-beam there is at the outer end a somewhat shorter lever arm which, through a connecting-rod, is united to the wheel of the locomotive. On the axle of the locomotive moved in this manner are the eccentrics, which, through several coupling rods, set in motion the valves, lying likewise inside the boiler. The bearings of the upper half-

beam are arranged on the front plate and on the cast iron frame which carries the whole boiler.

"The wheels, and their connection by horizontal coupling rods, are arranged as in the locomotives previously described. This locomotive shows the improvements in those designed for the Darlington Railway with some not inconsiderable additions.

"The principal faults of the locomotives at present are still that they are not constructed sufficiently durable and therefore require many repairs. This locomotive works with 45–52 pounds per square inch on the cylinder area, and in doing so is said to perform the duty of 15 horsepower."

It will be seen that this description is fairly complete, although there is an apparent discrepancy in the particulars of the boiler, as an internal drum 3½ft. long would not reach the chimney end of the flue by some 5ft. They were apparently unable to ascertain the piston stroke accurately, and did not give the crank length. No indication of the position of the wheels was given.

The water-tube grate is clearly described, this being the only known account of its construction, but they do not tell us how the tubes were fixed in their headers. The existence of a central water chamber in the flue was a new feature, and suggests the influence of W. H. James's patented boiler, which the Stephensons were authorised to use by an agreement made with William James in 1821.

When translating the Prussians' report, the writer doubted the correctness of the description which showed the lever shafts, through which the power was transmitted, mounted above the boiler, instead of near the footplate, which appeared to be a better position. The discovery of Rastrick's sketch of January, 1829, shortly afterwards (see Fig. 1) showed, however, that the description was quite correct in this respect.

Rastrick's description of the engine is as follows:—

"1829. 21st. Jan'y. at Stockton.

"This morning saw the Engine last sent by G. Stephenson; it was originally upon 4 Wheels, but being too heavy for the Road, it was obliged to be laid aside as it broke and bended the Rails.

"It is now on Six Wheels and has Springs under each pair of Wheels. The Weight of it with the water in the Boiler is 10 Tons. 2 cwt. 0 qr. 0 lbs. The Boiler is 4 ft. Diam^{r} and long. The Fire Tube goes quite through the Boiler and is Inches Diam^{r}—The chimney is In. D^{r} & 16 ft. high above the Rails, the Wheels are of cast-iron 4 ft. D^{r}—The two Cylinders are within and come out of the End of the Boiler. They are each 9 inches diam^{r} & 2 ft Stroke.

"On the Tender of this Engine is a W^{t} Iron Cistern 4 ft. sqr & 2 feet deep containing 32 Cubic feet of Water or 196 Gallons, which will last the Engine from Stockton to Darlington a distance of 12 Miles, taking 20 empty Waggons the Engine and Tender, in all 39 Tons, at the rate of 12 Miles per Hour."

A marginal note gives the weight of the empty wagons as 25 tons, and the weight of the tender and coal as 3·9 tons.

Rastrick's description, unfortunately, abounds with blank dimension spaces, although he gives the cylinder dimensions as 9in. diameter by 24in. stroke. It was therefore still uncertain whether the latter figure was really the piston stroke or the wheel crankpin stroke; if he measured it himself, it was more probably the latter, as the piston stroke was not easy to measure directly.

It will be seen that the cylinder arrangement was a reversion to that adopted by Richard Trevithick in his Newcastle locomotive of 1805, but with two cylinders even more effectively steam jacketed by their complete enclosure in the boiler. This, however, had the disadvantage that the boiler had to be opened up to get at the slide valves, unless the cylinders were entirely withdrawn through the end plate. The cast iron end plate of the boiler was, no doubt, made flat to facilitate the attachment of the cylinders and flue, while the front end was dished as usual. The curious feature of a sliding extension to the chimney, mentioned by the Prussians, may have been intended to increase the draught through the restricted flue area round the central water drum, which area was 0·953 of the chimney area, while there was only 0·4 of the chimney area at the end of the grate. In the earlier engines the flue area was 1·64 times the chimney area, and the area at the end of the grate was 0·74 of the chimney area.

Rastrick's sketch shows that the boiler was supported at the rear end on a cast iron cradle provided with extensions, or wings, to carry the bearings of the upper lever shaft and the lower radius arm shaft. The upper levers and lower arm, in conjunction with the short link attached to the piston-rod head, constituted a simple Watt parallel motion.

It is interesting to note that this form of parallel motion was also used on the next two Stephenson engines, works Nos. 9 and 10, which were sent to France in 1828, and from a drawing of those engines, discovered in 1927, it is evident that they had a piston stroke of 24in. with a radius arm length of 37in.

According to the rules for the correct proportioning of such a parallel motion, given in Thomas Tredgold's "Treatise on the Steam Engine" (1827), the minimum length of the radius arms should be 1·5 times the stroke, which was, almost exactly, the proportion used on the French engines mentioned.

Rastrick's sketch is rather rough, so that accurate measurements cannot be made from it. From the Prussians' statement that the connecting-rod levers were shorter than the upper radius arms, taken in conjunction with the fair assumption that the wheels would have the standard crankpin radius of 12in., it would appear that the piston stroke was actually at least 30in., as stated by the Prussians.

A stroke of 30in. would indicate that the engine when designed, some time before June, 1826, was definitely intended to have a greater cylinder power than the earlier engines; in fact, its cylinder volume, with that stroke, would be identical with that afterwards adopted for the "Royal George."

It must be remembered, however, that it would be of no use increasing the cylinder volume unless the steam-raising capacity of the boiler was increased at the same time. Hence, in the "Experiment," the boiler flue was increased in diameter and length, a central water drum was introduced into the flue, and the grate was formed of water tubes, thus making its nominal heating surface some 70 per cent. greater than that of the four S. and D. Railway locomotives Nos. 2 to 5.

Even if this increase in heating surface was not entirely effective in producing enough steam to maintain the full pressure in the cylinders when running, the increase of the stroke to 30in. would, with the unequal lever drive adopted, have the advantageous effect of increasing the torque on the driving axle at starting to an amount equal to that obtained from a 10in. cylinder with a direct crank connection. That this engine was intended to be more powerful than the engines of the "Locomotion" type is confirmed by the Prussians' report, which records that the actual horsepower of the latter was stated to be 10, while that of the former was stated to be 15.

By Tredgold's rule for parallel motions a 30in. stroke would require a minimum radius arm of 45in., but it was found impracticable to get in an arm length of more than 36in. when laying out the gear in accordance with Rastrick's sketch, although such a proportion would, of course, increase the inaccuracy of the motion. Calculation shows that while the mid-point of the link will be truly on the cylinder axis at the middle and ends of the stroke, yet, at a point near each end of the stroke, the error would be as much as 0·05in., which is more than twice the error occurring in the parallel motion on the engines sent to France. Such an error, if the pins of the motion were well fitted, would lead to excessive wear in the piston-rod gland and packing, and such a state of affairs may be the basis of J. W. Hackworth's strange tale, quoted by R. Young in "Timothy Hackworth and the Locomotive," to the effect that the pistons required repacking after every trip from Darlington to Stockton. It is incredible that the pistons would require repacking after a run of only 12 miles, especially if metallic packing was used, and it would probably have required half a day to do the job. If, however, John Hackworth had meant to say piston-rods, the reason for it could be found in the faulty parallel motion. This story, then, would tend to confirm that the proportions were thus imperfect.

Further light is thrown on this and other points by the particulars relating to this engine given in the Stephenson Ledger, and these will now be given.

As already stated, the foundry account relating to travelling engine No. 8 commenced in the quarter April–June, 1826, and terminated in the quarter October–December, 1827. The castings are grouped according to the price per cwt., and the prices are generally lower than those for the earlier engines. The highest price was 21s., and the lowest 14s. per cwt. Ten separate groups are given, with four price classes, and, in this case also, it has been found possible, by their weights, to allocate fairly well to each group the particular parts of the engine included in it.

There is only one possible group which could include the cylinders, and this occurs in the quarter April–June, 1827. If therefore the visit of the Prussian engineers took place in April of that year, they probably saw the cylinders either in the foundry or in the works being prepared for use. As the cylinders for a 30in. stroke would be about 38in. long, it seems reasonable to suppose that they estimated the stroke from the length of the casting. Further, if the cylinders had a stroke of only 24in., their weight would have been less than that of the cylinders of the earlier engines, because the large middle flange must have been reduced in size and incorporated with the end flange of the casting. Actually, however, the weight given is greater, and even if the valve chest were included in this group, which seems certain, there is still a deficiency which would be just balanced by an addition of 6in. to the cylinder length. The writer therefore regards it as certain that the piston stroke was actually 30in.

The first castings group in the Ledger, dated April–June, 1826, amounts to about 24 cwt., and is found to fit the weights of the main frame, the boiler cradle, and the frames carrying the driving shafts, &c.

The second group, dated October–Decem-

ber, 1826, of some 6 cwt., covers the boiler end and tubular axle-box, while the third group of 2 cwt. 0 qr. 20 lb., priced at 21s., and of the same date, evidently accounts for the two headers at the ends of the water-tube grate.

The heaviest item (January–March, 1827) weighed 27 cwt. 1 qr. 6 lb. This was 30 lb. above the weight of the heaviest pattern of two-piece wheels, seen by the Prussians on S. and D. engine No. 5, and may certainly be taken to represent the wheels, which are of considerable interest, as they appear to have inaugurated the webbed type of rim so much used afterwards. Working back from Rastrick's sketch of January, 1829, which shows eight-spoked centres and webbed rims, through the fact that the Ledger weight for the extra pair of centres supplied for this engine, in August, 1828, showed that they must have been of the eight-spoked pattern, leads to the conclusion that this form of centre must have been supplied for its first wheels in 1827. On this basis, the weight left for the rim was much greater than that of an eight-spoked rim, and exactly agrees with the calculated weight of a 48in. webbed rim.

The total weight of 75·74 cwt. of castings in this engine was 34·5 cwt. more than the castings in the engines Nos. 4 to 7. It would therefore appear that considerable weight reduction must have been made in other directions, as the engine was sent for trial, in November, 1827, with an unladen weight of 6·75 tons. As little could be done to reduce the weight of the driving gear, it is evident that the boiler must have been very much lightened, as was possible because the removal of the cylinders to the end avoided the necessity for a very stiff barrel. It was found necessary, in fact, to reduce the plate thicknesses to the minimum required by the steam pressure, and to adhere to the Prussians' inner drum length of 3½ft.

It is evident, from the correspondence of November, 1827, relating to this engine, previously quoted, that its designed weight was considerably more than that of the earlier engines, and if it was intended to work with the same adhesion factor then its weight in working order, in proportion to the cylinder volume, should have been about 10·5 tons. Its calculated weight, as a four-wheeled engine, is, however, found to be about 9·42 tons, and it did not exceed 10 tons until it was placed on six wheels and springs in the summer of 1828.

The problem which troubled Warren then arises, namely, how this engine, which weighed 7·39 tons light in January, 1828, could be sent for trial on the Darlington Railway in November, 1827, with a weight of 6·75 tons. The writer's explanation is that Messrs. Stephenson, in order to comply with the requirements of the railway company, removed from the engine certain parts which might be considered as non-essential for its proper working.

A reduction of some 13·5 cwt. was necessary, and it seems certain that the greater part of this was obtained by changing the heavy two-piece wheels for a set of light one-piece wheels, which would account for nearly 10·75 cwt. We are in somewhat of a difficulty as regards the remaining 2·75 cwt., which might be covered by the removal of any one of three items, namely, the chimney extension, the feed-water heater, or the boiler lagging, the calculated weight of each of which is nearly 2·5 cwt.

Now the presumed reason for the provision of the chimney extension seems to make its removal very improbable, while the feed heater, although not essential, would involve considerable pipe alteration. The third alternative of removing the boiler lagging, although it might involve some loss of boiler efficiency, would be very easy to carry out, and is perhaps the most likely solution of the problem. On the assumption that the wheels were so changed and the lagging removed, the reduced weight, based on the calculated total, would be 6 tons 15 cwt. 1 qr. 6 lb., which is only 34 lb. more than the guaranteed figure.

(To be continued)

Soil Cement Stabilisation*

While soil cement paving is an accepted form of construction for roads and runways in America, no large-scale construction has as yet been carried out in this country. The following notes describe the first full-scale tests to be attempted here, using agricultural machinery.

A fairly level rectangular field, approximately 4 acres in extent, had been acquired for conversion into a steel yard, and the Cement and Concrete Association, of Grosvenor Gardens, London, was asked to recommend a cheap and speedy system of construction. The requirements were to provide with the limited labour available, in the shortest possible time, a firm, even surface, capable of bearing wheel loads of up to 3 tons on pneumatic tyres, for the storage and removal of steel sections up to 5 tons in weight, and loads generally imposed in the construction of vessels of up to 600 tons displacement. Cement stabilised soil paving was decided on as the appropriate solution, and the work was carried out by the Independent Construction Company, Ltd., of London, which is specialising in such work.

The subsoil from 9in. to 1ft. below the surface was a sandy clay, probably unsuitable for this treatment, but since the grading necessary to provide a cross fall of 1 in 150 did not expose this subsoil, it was possible to provide 6in. thickness of soil cement paving by treating the top soil, which was of a silty nature. The subsoil, except at one corner of the field which required special treatment, was sufficiently firm to enable compaction to be effected by means of an 8-ton roller. The surface soil actually used for the paving was a fine silt loam varying slightly over the site, but all coming within the classification A4 of the American Public Roads Administration. Owing to the unusually high percentage—63·5—of fines passing a 200-mesh sieve, from 15 per cent. to 18 per cent. of cement by volume would have been necessary to stabilise the top soil in its existing state, but since a gravel pit supplying 1½in. down "all-in" ballast was adjacent, it was decided to add one-third of this material to the soil, thereby improving the grading and reducing the fines to nearly 40 per cent.

The cement content decided on to stabilise the improved top soil was 12 per cent. by volume, which, owing to the experimental nature of the work, was deliberately chosen on the high side. Since the size of the work was not sufficient to warrant bringing heavy plant from a distance, only special units were supplied by the contractor, agricultural implements and the smooth roller, lorries, &c., being hired locally. The plant employed was one "Caterpillar" grader No. 12, with 12ft. blade, one "Caterpillar" D.4 tractor, one Fordson tractor, one double-furrow plough, one offset disc harrow with 22in. discs, one agricultural cultivator, one Yorkshire spiked harrow, one chain harrow, one sheepsfoot roller developing 300 lb. per square inch pressure, one pneumatic tyred roller (3 tons on nine wheels), one 8-ton diesel roller, one water distributor, and one flat trailer for distributing cement.

The gravel was brought on to site and tipped in place by the supplier's lorries. The water distributor was improvised and consisted of three 200-gallon ship's water tanks mounted on a 6-ton lorry coupled together and feeding a 14ft. wide spray bar fitted at the rear through a small petrol-driven centrifugal pump. In effect this apparatus, partly through slowness in filling, proved to be rather on the small side for the work. The labour, apart from supervision, consisted of one foreman, one grader and roller operator, two tractor drivers and six labourers, and with this force it was possible to pave 1200 square yards 6in. deep, per eight-hour day, although it may be noted that the agricultural equipment, rollers, &c., were in use for only a fraction of the time during which they were hired, and that, given perhaps one extra tractor and more labour, the same equipment could have paved an area up to six times the size. A small field laboratory was established in a shed near the site at which field tests could be carried out. A drying oven and apparatus for the Proctor density tests were installed, but the only essential apparatus was a chemical balance, primus stove, and a few dishes, with which a rapid determination of the moisture content of the soil could be made from time to time as the work proceeded.

The sequence of operations was as follows:—(*a*) The weeds were raked off with a Yorkshire spiked harrow, turf bordering the site being stripped by hand. Level pegs were set out at appropriate spacing, giving a cross fall of 1 in 150. (*b*) The surface was graded with the No. 12 grader and given a preliminary treatment with the double-furrow plough, cultivator, and disc harrow, the two tractors pulling these implements by turn. Soft spots were tightened up with a few passages of the sheepsfoot roller. About 10,000 square yards were graded and so treated in one day. (*c*) The site was divided into areas of about 1200 square yards, each representing one day's work with the labour available. Gravel was brought on to the first section, tipped at intervals as required, and spread to an even depth of 2in. with the grader. It was then thoroughly mixed with the soil by frequent passages of the agricultural implements until the soil, apart from the gravel, was pulverised so that 80 per cent. passed a ¼in. sieve. (*d*) This process was continued on the following day over the next section, while the cement bags were laid out on the first section, one bag to every 2 square yards. This work proved to be the longest operation, six men taking four hours to double handle the 600 bags required from the stock pile on to the trailer and thence on to the site. This left insufficient time to complete the process during working hours. Since it was impossible to obtain sufficient labour to spread the cement in two hours, it was later decided to risk the effects of heavy rainfall and to spread the cement protected by the bags directly on to the ground the day before from the supplier's lorries, thereby avoiding double handling and enabling the labour to be steadily employed. (*e*) Bags were opened and paper removed. Cement was spread evenly with the spike and chain harrows in tandem and then thoroughly mixed with the soil and gravel by repeated passages of the cultivator and disc harrows until the whole assumed an even colour to a depth of 6in. (*f*) The water content of the soil at the time having been determined, the addition required to bring it up to 12·8 per cent. plus 2 per cent. evaporation allowance on hot or windy days was calculated in terms of passages of the distributing lorry. This operation took nearly forty minutes each trip, including the filling, so that with the improvised apparatus available the watering was perhaps the second longest individual item of the process, for although normally less than 5 per cent. of water had to be added, this represented over 1200 square yards, more than four trips of the lorry. It will be appreciated, therefore, that so long as the cement is sufficiently protected, some showers of rain, so long as they are not sufficient to clog the soil and hinder mixing, may, so far from doing harm, be beneficial in reducing the watering operation. (*g*) For the wet mixing the water distributor was followed by the spike harrow, the cultivator, and disc harrow, three or more passages of each being advisable according to the nature of the soil. (*h*) The sheepsfoot roller was next brought on and the ground rolled until consolidated to a depth of 3in. The grader was then run over to check the grade and sheepsfoot rolling continued until the feet penetrated to a depth of only about 1in. The final passages of the sheepsfoot roller were followed up by the spike harrow either in tandem or separately. (*i*) The ground was rolled with the pneumatic-tyred roller and finished to grade with the

* Communicated by the Cement and Concrete Association.

8-ton diesel flat roller. (*j*) It was then covered with damp ashes for curing, spread by the grader, and watered at intervals next day. The soil by that time had hardened sufficiently to withstand the weight of the 600-gallon distributor without marking, the water running off the surface without any tendency to form mud when rubbed.

At any time after the conclusion of these operations the surface would have been suitable for light or heavy slow-moving traffic and during the next week greatly increased in strength. Since, however, the surface is intended to withstand not only loading, but also attrition caused by dragging about steel plates and lifting their edges with crowbars, it was decided to protect it with a light tar spray dressing and chippings.

South African Engineering Notes

(By our South African Correspondent)

CAPE TOWN, April 29th.

Hunt for Rubber

THE British Resident Minister in West Africa, in an interview given in Cairo recently, said Africans were combing the forests of Nigeria, the Gold Coast, Sierra Leone, and Gambia for wild rubber to compensate for the loss of the Malayan plantations. Before the war West Africa produced no rubber. The people, he said, had entered with such zest into the treasure hunt that British West Africa last year produced three times as much rubber as the Belgian Congo.

Canning Control

Regulations controlling the production of canned foodstuffs have just been published. The regulations prescribe the marking of containers and also the manner in which fruit, vegetables, and jams may be canned. Other regulations included notices relating to the control of building materials, timber, and textiles, and the maximum prices of certain brands of blankets, handkerchiefs, knitting yarns, hats, and other articles.

Irrigation Schemes

Senator Conroy, Minister of Lands and Irrigation, informed the Union House of Assembly just before the close of this session that provisional plans had been drafted for a great irrigation scheme on the Orange River. It was tentatively proposed, he said, to construct a dam at Bethulie which would enable water to be taken hundreds of miles in canals to the North-West Cape. Some 300,000 morgen of land—10,000 30-morgen farms—could thus be irrigated. This scheme, observed the Minister, should enable the North-West Cape to be converted into "a paradise." Senator Conroy gave no details of the scheme. In August last, however, in a speech at Germiston, he gave a few pointers. The Caledon River, he said, would be dammed near Ficksburg, from the dam water was to be led through the Witteberg by a tunnel, 21 miles long, to the other side of the mountains, where no less than 3000 farms would be irrigated. Three dams would be necessary in all, and the total area of irrigated land would be from 50,000 to 60,000 morgen, and some 7000 to 10,000 people would be given employment in carrying out the scheme. Senator Conroy also mentioned another scheme which would involve a further impounding of the waters of the Orange River. He gave no details, but said that it would be six times the size of the Caledon River scheme. His reticence was no doubt due to shortage of staffs in Government and other Departments, for it is hardly possible to expect those remaining to be able to furnish details and plans of such enormous projects, but beyond that there are other considerations, which one understands have had the effect of bringing about what amounts to an embargo on the dissemination of information relating to construction works, such as these, and other construction works undertaken by other departments—the wisdom of such a step in the case of construction works, &c., at the Union harbours is, of course, obvious during the duration of the war.

Boots for Union Army

The Army Boot Committee is to meet in Port Elizabeth on May 4th to survey the changed situation which has been brought about by developments in the war, notably the shortened supply line between the Eighth Army and Britain. The forces in the Middle East can now be supplied more easily from Britain and from America, *vid* the Atlantic and West Africa, than from South Africa. In the meantime, footwear factories here and elsewhere in the country still have contracts for more than 1,000,000 Army boots this year. The present output is 15,000 pairs a month. One of the questions for the Army Committee is the supply of the mature hides needed for Army boots and obtained only from mature animals, the demand for which has been such that a shortage was threatened and the Leather Controller has restricted the export of certain classes of hide until S.A. requirements have been met. Factories not supplying Army boots are going all out to meet civilian demand, but in many cases retailers' orders have to wait months to be filled.

National Roads Progress

The position of the National Roads Programme, under which some 6000 miles of National Roads are to be constructed of first-class material and fully bituminised at a cost of some £26,000,000, is not regarded as satisfactory. Apart from the great delays caused by the war, which has not only taken away for construction work on many parts of the African war theatre many road engineers and skilled workmen, but much of the road-making machinery, there are also allegations of inefficiency and waste. A revision of National Road Board policy is recommended by the Union Parliamentary Select Committee on Public Accounts in its latest report. The Select Committee expresses agreement with the former Chairman of the National Road Board, Colonel P. I. Hoogenhout, that the position generally is unsatisfactory, and endorses his view that the system under which provincial administrations are responsible for the spending of national road funds is unsound. Colonel Hoogenhout, who resigned last March to take up a new post, in his evidence before the Board at his resignation, said there was evidence of neglect.

At present the Board is mainly building military roads and has put at the disposal of the Government all its equipment. There is meantime a large mileage of partly made-up roads in the Union, which for want of completion, especially bituminising, are deteriorating to an extent which can be calculated at a huge yearly financial loss.

Rhodesian Mines

Despite wartime handicaps and a rather belated appearance, the "Rhodesian Mining Year Book," which has just been published in slightly less bulky form than usual, contains all essential details in regard to the development of the mining industry and constitutes a permanent record of the activities of the leading mining companies north and south of the Zambesi. It is interesting to note that a record mineral output was achieved in 1942, the slight decrease in the gold output being offset by an increased production of base metals.

Map of Rhodesia

A map of Southern Rhodesia which will not be available to the public while the war lasts is about to be completed. It is the first large accurate map of the Colony, revealing the height above sea level of all parts of the country. The work is being carried out by the Surveyor-General's Department. This topographical map, which has a scale of about 8 miles to the inch, is four times the size of the biggest existing map of Southern Rhodesia, which was completed a decade or so ago.

Railway Earnings

Railway earnings of the South African Railways have, contrary to expectation, risen higher during the first four months of 1943 than during the last four months of 1942; and in one week topped £900,000, but the average was not above £840,000 per week, if as much. For the week ended April 24th the earnings only totalled £807,564, but even so it was well ahead of the total for the corresponding period of 1942, when the earnings only reached £785,145. Goods and passenger earnings are the principal sources of the earnings. For the week ended April 24th passenger earnings were £260,856, against £159,530; goods earnings were £398,641, compared with £470,243. Passenger earnings benefit greatly by the large number of troops being carried, both for Service and on furlough.

S.A.'s "Little Ships"

Much praise has been given to South Africa's little ships which have won fame by their fine work in the Mediterranian, but not many people know that most of them are German-made. They came to their present naval respectability in an unusual manner. Formerly whalers, they were bartered by the Germans not long before the war for oil. Owing to their currency problems, the Germans could not afford to pay for the oil in cash, so they handed over the fast new whalers. They operated for a South African firm (Lever Brothers) in the Antarctic. When war broke out they were recalled. From whale-chasers they were equipped with the latest devices at a cost of many thousands of pounds.

New Steel Works

The Van der Bijl steel works, the construction of which began nine months ago, are expected to produce armour plating in August. Near the works is the site of the Van der Bijl township, which eventually will be inhabited by 100,000 men, women, and children. Work is going along on a railway track leading to a bay which will be large enough to take a locomotive and six trucks. Heavy plate mill machinery is being installed. It is this plant which is expected to produce armour plating within four months.

Large Electric Motor

The largest electric motor so far made in South Africa has just been completed. The motor, whose rating is 2250 H.P., has been built by a Rand gold mine engineering staff and a Johannesburg firm of electrical engineers. It is intended to be used for pumping and dewatering underground. It took six months to make and has been built by South African labour and to purely South African design.

The Future of the Tinplate Industry

FURTHER reference to the future of the British tinplate industry is made by Mr. E. H. Lever in his chairman's statement to the ninety-fourth annual general meeting of Richard Thomas and Co., Ltd., which is to take place at Grosvenor House, London, on Friday of next week, August 20th. Mr. Lever says that as befits a company of its standing, it is taking a leading part in attempting to solve, in collaboration with the rest of the tinplate trade, the two outstanding problems of redundancy and reconstruction. Few there are in the trade, Mr. Lever says, who are not now convinced of the urgent necessity of changing over a further substantial portion of plant to the modern process of manufacture. The policy of Richard Thomas and Co., Ltd., is to endeavour to find a means of achieving this end on a co-operative basis. With regard to the firm's own plant, no opportunity of increasing its efficiency is being overlooked. In keeping with the latest developments in the United States, it is the intention of the company to install at the earliest practicable moment an electrolytic tinning unit in connection with the Ebbw Vale plant. This is being done with the hope that not only will practical experience be gained with one of the latest developments, but the pioneer work of the company in this particular direction may lead to a wide extension of the use of the company's products to the ultimate benefit, not only of the company itself, but of the tinplate trade and the community generally.

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ENEMY AIRCRAFT LOSSES

In view of the increasing influence in warfare which the Air Arm has been found to possess, it is of value to assess as carefully as one can the relative trends in the numerical strengths of the two sides in the present conflict. Although numbers alone do not suffice to decide issues, they have an influence which can only be neutralised when the smaller air fleet has a marked advantage in quality of aircraft or personnel or both, as was illustrated in the Battle of Britain, when we possessed them both and gained a decisive victory despite our lack of numbers. What is the position reached to-day when to the high quality of our aircraft and the fighting ability of our men is added the advantage in numbers which we, the Allied Nations, now possess?

Figures of total strengths are not published by either side, but those of losses are frequently given—though not invariably. How accurate these estimates may be is often questioned. They may err by inadvertence, or they may be purposely misleading; there is nothing wrong in refraining from publishing losses when by so doing one conceals from the enemy useful information which otherwise he would lack. This is frequently seen in respect of ships, naval and otherwise. But in the case of the war in the air, we, with our Allies, have commonly given our figures for losses, and if Press reports are to be credited, the enemy has confessed that our figures cannot be gainsaid. Nor are we aware for our part of any marked discrepancy between our estimates of German losses over this country and his own figures. This may be thought a somewhat grudging admission, but when one is dealing with an enemy who has publicly claimed "lying" as a natural weapon to use in time of war, one has to watch one's step. It is true that in "Mein Kampf" it is only really big lies that receive the highest commendation, and it may well be that in air warfare, where both sides are bound to see at least part of what is happening, the really big ones are difficult to stage. When, however, the communiqués issued on the Eastern Front are studied, the conclusion is reached that for some reason the enemy command argues differently. As a consequence, the figures issued by the two sides appear to have no connection with each other. They might relate to different battles or at least to different dates. A curious streak runs through them—if the Russians claim 150 of the enemy shot down for, say, 15 of theirs, the Germans roughly invert the figures, it being a fixed rule, however, that the admitted German losses must always be the lower. Whom this is intended to deceive is not clear, but whom it is likely to mislead is plain enough, for that is no one. The only instance in the west where, in the nature of the case, it is exceedingly difficult to assess the correct figures is when a closely knit well-armed bomber formation is attacked in daylight by enemy fighters. Then there are bound to be occasions when two or more gunners fire at the same time, unknown to each other, at an enemy fighter which is seen to burst into flames. Duplication of claims in such cases is natural and only the closest scrutiny afterwards can decide what happened. It is known, however, that the Americans and ourselves have systems of scrutiny in force which ensure that so far as is humanly possible the figures arrived at are correct, and certainly they are honest.

If we make an assessment of enemy losses and compare them with his probable rate of construction, a definite and very remarkable trend can be seen. The daily losses of the enemy Air Arm, as shown by the various communiqués, are at the moment highest in the Mediterranean area and on the Eastern Front. If we estimate the present average daily loss in combat of 50 enemy aircraft on each front and allow half as much again for the effect of aerodrome attacks which destroy aircraft in hangars or on the ground, and for losses through faulty piloting and navigational errors when returning from sorties and during training, we shall be on the safe side. This gives an average daily loss of 150 aircraft. As regards construction, we are told that in America over 200 new aircraft are produced each day. No other country touches that output. It used to be considered that the Axis Powers in Europe could produce 100 aircraft a day, but that was before our intensive air attacks on the Ruhr and other industrial areas, to say nothing of those in Italy. If the present output is 70 a day, including training machines, the enemy is fortunate. It may be much less. But only one end can be reached with an income in the neighbourhood of 70 and an expenditure in the neighbourhood of 150, for that means a net loss of well over 2000 a month, and even if his aircraft in use or in reserve still amount to as many as 5000, the day of reckoning must be coming close when the *Luftwaffe* will crack once and for all. The enemy's hope must be that the rate of losses will fall, but as the strength balance tilts increasingly against the Axis Powers, their proportionate rate of loss will rise until enemy aircraft have to seek to avoid air combat. This it is difficult for them to do as we can meet such evasive tactics by persistently bombing targets of such importance that it is vital that some air defence be attempted. Indeed, there are signs that that state of affairs is already being reached, and unless the enemy can immediately produce something far better in quality than anything now flying on either side, a collapse in his air defence must soon come.

Oliogopoly

The advances of science call for the creation of new words, either to express new mental concepts or to reduce a cumbersome phrase to a single unit. They are sometimes embarrassing and not always patently necessary. Contrast, for example, the two now-familiar words, entropy and enthalpy. The first is a convenient handle for a complicated definition. We did without it for years, or knew it as Rankine's Thermodynamic Function, but it has become essential. Thermodynamic life without it would now be impossible. But enthalpy, which means no more than total heat between prescribed limits, is an unnecessary addition to scientific jargon. There is nothing the least bit recondite about enthalpy and in its normal dictionary meaning it is in no way better than the old-fashioned "total heat."

America is the home of new words and phrases. Many of them are, so to speak, struck out of the soil—take that delightful mouthful "bulldozer," for an example. Some are recovered from the literary scrapheap like "serendipity"—due to Horace Walpole—which deserves to come into currency for "accidental discovery"; some have no pride of ancestry, and, we trust, no hope of posterity, such as "boondogling," the meaning of which eludes us—see THE ENGINEER, September 20th, 1940. Yet others seem to be introduced, like the barking canary in the boy's riddle, "to make it more difficult." Sometimes they have a specious appearance of deep learning, not infrequently marred by imperfect knowledge. Such an one is "oliogopoly," used by Mr. William Gomberg, of the International Ladies' Garment Workers' Union, in an address to the A.S.M.E. in January last. What precisely it is meant to imply, we are not certain. Only ought we to say, here and now, that it has no specific

connection with international ladies' garments. "Poly" at the beginning of a word means 'many'; at the end it conveys the sense of selling, as in 'monopoly.' So far, so good. Mr. Gomberg's word has something to do with selling. That fits in with his text. But what about "Oliog"? Is the printer responsible for the second "o" or did the author write it and mean to? If we dare omit it then we should have 'oligopoly,' which would be fair Greek for "few-selling." That is not a dictionary word and it is hard to see that it is really needed, even in the new science of industrial economy. Mr. Gomberg's sentence runs: "He [the worker] must believe that increases in production actually mean proportionate decreases in prices; that the price structure of economy is completely rational rather than restrained by the imperfect laws of oligopoly." The American worker in International Ladies' Garments must be far better grounded in Greek than his British brother, if he would find his misgivings about increased production diminished by such an assurance as that for which Mr. Gomberg asks

We have dwelt upon this almost trivial introduction of a new word, not merely to expose its error, but because it is symptomatic of a practice which should be kept in check. Not for a moment do we object to the creation of words when the progress of thought or science really requires them. But this multiplication leads to eclecticism, to the hiding of meanings from the uninitiated. It is one of the causes why science is forbidding to the general public, and it is particularly to be deprecated when one is dealing, as Mr. Gomberg was, with a subject which, in the new vision, should be as clear to the worker as to the philologist. The less formalism that is used in the science of economics, the more is it likely to be apprehended by those directly affected by it.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE BRITISH OIL ENGINE INDUSTRY AFTER THE WAR

SIR,—Before the last war the British production of internal combustion engines was leading in the world market. After 1919, however, our position deteriorated rapidly and the Germans went far ahead, particularly when the direct injection diesel engines gained so much favour and replaced the air blast engines.

It might be of interest to know that before this war one single German firm alone was supplying over 1½ million horsepower per annum and produced more than 50,000 engines a year, which the world market readily absorbed. They were constantly enlarging their works, whilst the British industry lagged sorely behind.

It would be fatal if internal combustion engine works were acquired and managed as if they were multiple grocers' shops. To regain and maintain our lead, the executives, such as managing directors and sales managers of the diesel engine industry, as well as the members of the committees affecting the diesel engine industry in general, should be chartered mechanical and/or marine engineers who have had ample experience with diesel engines. They alone are qualified to study the markets and keep constantly in closest touch with the merits of the indigenous and foreign competitors and also with the particular requirements of the shipping and other industries. The recent formation of the British Internal Combustion Engine Research Association is an indication that we do realise we must make a move so as to regain our previous position. At the head of this new Association is Mr. Charles Day, of Mirrlees, Bickerton and Day, Past-President of the Institution of Mechanical Engineers. His name has always been connected with the success of the British diesel engine industry.

The Research Association is at present limiting its consideration to stationary and portable land engines, marine engines (propulsion and auxiliary) not exceeding 1500 H.P., and oil engines for railway locomotives. It would be preferable to subdivide this further and make a more special study of engines not exceeding 1000 H.P., and, even so, the field is a colossal one, as every engineer will agree.

Considerable discussions have so far taken place as to the types, sizes, speed, and standardisation of engines. Whatever we do, however, we must bear in mind that we have to consider this matter, not from our more singular point of view of what suits us best, but what the world market requirements are.

MARCEL PORN,
M.I. Mech. E., M.I. Mar. E.

London, S.E.1, August 8th.

LOCOMOTIVE EXHAUST

SIR,—In your leading article of to-day's date you raise the question of the smoothness of draught which may be produced by a multiplicity of exhausts, a proposition which seems to be perfectly reasonable; but is it true? I remember a small experiment which indicates that it is not. The engines concerned had fire-doors of two flat plates sliding towards one another, and they were normally kept about 1in. apart. One day the driver had just lit his pipe, and to amuse me put the spent match across the opening of the fire-doors, where it was, of course, held by the draught, but it jumped with each puff of steam, quickly got into a vertical position, and shot into the fire-box. A week later I was on a two-cylinder compound of about the same size, and pulling about the same weight of train, and I repeated the experiment. As there were only two exhausts instead of four, I expected the match to drop off between the puffs, but, on the contrary, it remained absolutely stationary, as if glued there, until I had to open the doors to put more coal on. Evidently the draught was much smoother and more uniform. From this I deduced that the smoothness of the draught depends mainly on the steam being properly expanded in the cylinders, and having the sting taken out of it before it is thrown up the chimney, and that the number of puffs does not make any appreciable difference.

R. C. PORTER.

Birmingham, August 6th.

Twist Drills Order

THE Ministry of Supply is issuing a new Control Order to become operative on August 16th, 1943, known as "The Control of Machine Tools (Twist Drills) (No. 1) Order, 1943," which concerns all persons using high-speed steel twist drills.

The Order makes it illegal for any person to place orders for high-speed steel twist drills of certain standard types and sizes in quantities greater than those indicated in the following Schedule, during certain periods of six months' duration. Users should make themselves familiar with the terms of the Order, and this communication must be regarded only as conveying certain information and guidance to persons who may apply for a licence, and not as an authoritative statement of the construction or effect of the Order.

High-speed steel twist drills of the following descriptions.	Quota for any licence period.
A. Standard, up to and including $^{9}/_{32}$in. diameter, straight shank	2000
B. Standard, up to and including $^{9}/_{32}$in. diameter, taper shank	100
C. Standard, over $^{9}/_{32}$in. diameter up to and including ½in. diameter, whether straight shank or taper shank	200
D. Standard, over ½in. diameter, whether straight shank or taper shank	50
E. All other types (including Specials and left-hand twist drills) not covered above	500

Drills up to the numbers stated in the Schedule may be ordered during the six months' period without licence. Larger users, however, must apply for a licence, Form R.S. 15C, which can be obtained from the Controller of Jigs, Tools, and Gauges, from the Allocation Centre or from any Regional Director of Machine Tools.

TWIST DRILLS ALLOCATION CENTRE

In order to deal with the Control hereby instituted, and to facilitate the placing of requisitions for twist drills, an organisation has been founded, viz., the Twist Drills Allocation Centre, at 32, Kenwood Park Road, Sheffield, 10. The Centre will operate under the direction of the Controller of Jigs, Tools, and Gauges, Machine Tool Control, and is open to receive requisitions commencing on August 16th from users or re-sellers of twist drills.

Although the Control Order covers, and will therefore apply to the full range of high-speed steel twist drills, it is intended in the Allocation Centre as a commencement to deal only with standard twist drills of high-speed steel with Morse taper shanks up to 3in. diameter, including millimetre and fractional sizes, and also straight shank drills taper lengths up to 1¼in. diameter (both types rising by sixty-fourths and 0·5 mm. steps). No other types, either standard or specials, will at first be dealt with and due notice of extensions to other sizes and types will be given by the Centre from time to time as the organisation progresses.

PLACEMENT OF ORDERS

The placement of orders for H.S.S. twist drills, of the types and sizes quoted, by users whose volume of orders are such as to be below the number in all the categories in the Schedule to the Order may be made in one of three ways:—

(*a*) By submission of a requisition to the Centre when the advice of the Centre as to the most favourable source of supply will, of course, be available, based on the knowledge of the loading of all suppliers.

(*b*) By direct reference to any supplier on an official list, providing that the Centre has not been approached.

(*c*) By placement with a merchant house regularly engaged in the re-selling of high-speed twist drills.

Re-sellers wishing to place orders for H.S.S. twist drills of the types and sizes quoted with any of the suppliers listed must submit requisitions to the Allocation Centre. The Allocation Centre, having in mind the loading of the various supplier, will make suitable allocation and, wherever possible, will nominate the desired source of supply indicated by the re-seller.

All users and re-sellers must review all orders they have placed with any source of supply and relate these to their existing stocks and anticipated requirements, making whatever adjustments are necessary by mutually agreed cancellations with the supplier in question.

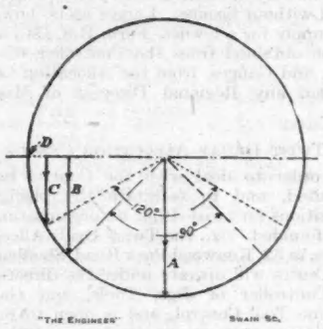
It is of paramount importance in the national interest that all orders, the execution of which cannot be considered strictly necessary for the prosecution of the war effort, be cancelled forthwith and active co-operation of user, re-seller, and supplier is requested.

To facilitate the work of opening the Centre, all suppliers have agreed only to accept emergency orders as from the date of this memorandum until allocations commence on August 16th.

Flexible Pressure in Veneer and Plywood Work*

By THOMAS D. PERRY†

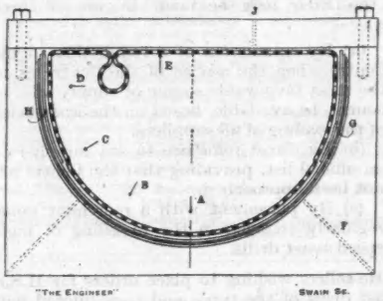
CURVED plywood has been made for many years and used in furniture, pianos, radio cabinets, doors, stair risers, and the like. The volume has been quite limited. The devices for obtaining curvature have been relatively simple so that they could be made by the factory mechanic, and the strength/weight ratios were not considered important. Improved methods for producing curves out of prebonded flat plywood, as well as of making curved shapes at the time the layers of veneer are glued into plywood, have both been in the stage of progressive development, but until quite recently without evidence of particular urgency. An earlier paper by the author, in comparison with the present paper, gives an interesting perspective, indicating the marked progress which has been made in the technique of curved plywood manufacture.



Indicating effect of curvature on unidirectional pressure, i.e., pressure at B is two-thirds that at A, at C is one-half that at A, and at D is nil.

FIG. 1—*Diagram for Vertical Pressure*

The distinct realisation of the outstanding utility of curved plywood of complex shapes for aircraft, boats, Signal Corps requirements, and other fighting equipment has given substantial impetus to these developments, and the progress made in the past two years has been most striking. Since plywood materials, equipment, and man power were found to be relatively plentiful, its adoption as an alternate for scarcer and more critical metals has greatly accelerated the development of new methods of pressure application for making intricate curved forms of plywood and related materials. The availability of heat-reactive resin adhesives has become another major factor in this expanding plywood programme.



Indicating that the flexible bag exerts pressure in every direction, and its intensity is equal at A, B, C, D, E, and other points. Vents are provided at F. Overlays are shown at G and H

FIG. 2—*Omni-Directional Pressure*

At this time it is possible to examine the principles underlying this new curved plywood technique, to evaluate them at least partially, and to outline some of the more important methods which have so far contributed to its rapid progress. The programme is making such strides that statements of to-day may be untenable to-morrow, and the visions of this week may become the facts of next. An outline of such industrial progress, as it occurs, needs no defence, nor does its obvious incompleteness require an apology.

PRESSURE IN ONE DIRECTION

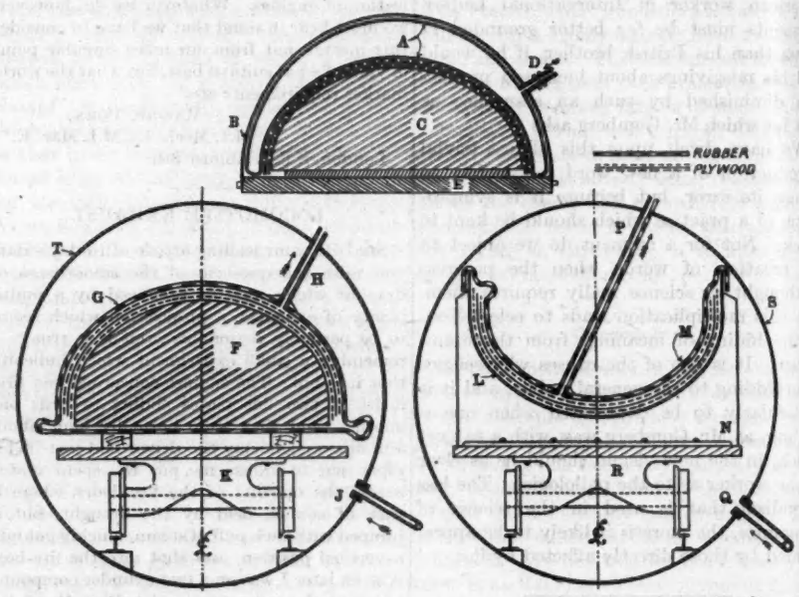
The standard method of exerting pressure, when gluing sheets of veneer into plywood, has been the application of pressure in one direction only, *i.e.*, by hydraulic rams or pistons, by pneumatic jacks, by screw presses or clamps, and, in rare instances, by toggle joints. Such pressure is distributed, more or less efficiently, over the area of the glue joint by rigid plates or blocks. This method of pressure application involves adjustments or corrections for certain inevitable differences of thickness which are common to all wood products and are suggested by the following examples:—

Veneer lathes and slicers are equipped to cut certain fixed thicknesses, often from logs or flitches which are cooked to the saturation point. It is well known that the shrinkage from such a saturation point or from normal greenness to working dry (approximately 10 per cent. moisture content) will differ, as between quarter-cut (radial) and plain-cut (tangential), and also will vary between sapwood and heartwood. Furthermore, there is no generally recognised standard for veneer cutting. Some operators cut to full dimension green, resulting in a scant thickness dry, while others allow a fixed shrinkage factor and claim to produce veneer of full dimension when dry. Another phase of the problem is that rough-cut surfaces require more pressure than smooth-cut veneer.

The practical solution to thickness variations, in regular plywood production, is adequate pressure to compress the thicker layers until they match the thinner layers, usually a reduction of 5 to 10 per cent. in aggregate thickness being required. This involves the use of more pressure than is needed otherwise, and requires the allowance of extra initial thickness in the veneers used.

Another problem in the use of one-directional pressure is that of somewhat curved or recessed surfaces, such as the well-known "Toastmaster" plywood tray, or a conventional barrel stave of plywood. In order to make a proper plywood bond, effective pressure should be exerted in a direction at right angles to the curved surface or perpendicular to a tangent. Vertical pressure, diverted at an angle, will be reduced in geometric ratio, as can be noted in Fig. 1, which is a diagram published in the original paper. Full pressure (*e.g.*, 100 lb. per square inch) will be exerted at A, while at the extremities of a 90 deg. angle (as at B) the pressure will be of the order of two-thirds; at the extremities of a 120 deg. angle (as at C) it will be one-half, and at D it will be nil. From a practical viewpoint, one-directional pressure can be made effective over a 90 deg. angle, sometimes over a 120 deg. angle, but there will be a moderate amount of surplus pressure required to compensate for the effect of the curvature.

There are some instances, relatively few in number, where presses or clamps exert pressure in two directions, as in a vertical and horizontal direction, but, in general, these two-way-pressure devices are not important.



Upper; Inflated Bag on Solid Mould
A—Inflated rubber mattress
B—Half steel shell to restrain mattress
C—Solid mould, wood or metal
D—Fluid pressure inlet to inflate mattress
E—Base plate to which B is bolted

Lower Left; Deflated Bag on Solid Mould in Autoclave
F—Solid mould, wood or concrete
G—Deflated rubber bag
H—Vacuum or vent connection
J—Fluid inlet to produce pressure in autoclave
K—Transfer car
T—Autoclave

Lower Right; Deflated Half-bag on Shell Mould in Autoclave
L—Shell mould of metal
M—Half-bag to be deflated
N—Cross frames to keep mould L rigid
P—Vacuum or vent connection
Q—Fluid inlet to produce pressure in autoclave
R—Transfer car
S—Autoclave

FIG. 3—*Methods of Applying Omni-Directional Pressure*

PRESSURE IN ALL DIRECTIONS

With this background in mind, it is possible to contrast the one-directional pressure through rigid plates, as outlined, with the recent developments in applying flexible pressure with a fluid medium, such as steam, hot water, or compressed air.

Fig. 2 indicates the same plywood construction which could be made with the pressure diagram of Fig. 1. However, in the case of Fig. 2 the pressure is exerted by inflating through J a flexible bag, as of rubber. As a result, it is omnidirectional and with a fluid pressure of 100 lb. per square inch, it will be noted that this full pressure without any diminution is effective at A, B, C, D, and even at E. Another result accomplished by this fluid pressure is the elimination of difficulties caused by variations in veneer thickness. In fact, extra layers of veneer can be placed at certain locations, as at G and H, where concentrated stresses may be expected for fastening devices or scarfed joints. If a heat-reactive resin is used, the moulds may be provided with steam pipes,

* Reprinted from *Mechanical Engineering*, June, 1943.

† Resinous Products and Chemical Company, Inc., Philadelphia, Pa.

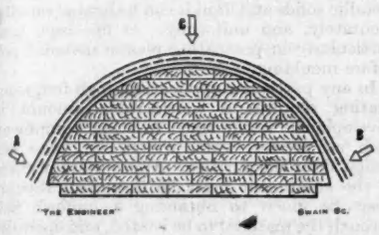
or the pressure fluid may be steam or hot water.

In the cross section, Fig. 2, the curvature might be that of a semi-cylinder, requiring curves in one plane only, or it might be a semi-sphere or semi-oval, involving compound curves in more than one plane. This latter shell-shape construction has been called "monocoque," and its best example is an egg shell, where strength/weight factors are found to have distinct advantages. In many monocoque designs bracing or stiffeners are found to be effective in improving strength characteristics, with less total weight than when the shell is thickened throughout for localised stresses. Such braced shells are called "semi-monocoque."

METHODS OF APPLYING OMNI-DIRECTIONAL PRESSURE

There are at least three principal methods of making monocoque plywood with flexible pressure bags :—(*a*) Inflatable closed bag or mattress not containing the plywood; (*b*) deflatable open-end bag containing the plywood; and (*c*) deflatable half-bag, or blanket, enclosing the plywood, in which the mould constitutes the other half of the bag.

In order to facilitate their comparison, Fig. 3 illustrates the same plywood shape made by each of these three processes. The cross section of this shape in the sketches might be one-half a fuselage or a boat hull. In the case of the fuselage, the two halves would be scarf-jointed and bonded into a whole. The shape, as shown, is intentionally reduced to its simplest form, and actually represents a cross section, in simple



The ineffective pressure at A and B, neutralised by banding of veneer layers, must be deducted from total pressure at C to get net effective pressure.

FIG. 4—*Effective Pressure in Flexible Bag Moulding*

curvature, or a cylinder or cone. In practice, this will probably have a considerable amount of compound curvature, for streamlined effects in either aircraft or watercraft. In order to make the details clearer, most of the layers or parts are slightly separated in this and succeeding sketches.

The upper cross section, Fig. 3, illustrates one of the earliest applications of flexible-bag moulding to plywood. The convex mould C may be of metal (with or without heat), of wood, or of concrete. The veneer layers, of which three are shown, are successively laid (technically, wrapped on) against the mould with adhesive between each layer. The outer and inner layers may be lengthwise of the mould, or at an angle of 60 deg. or 45 deg. thereto. The centre layer, like a half hoop, may be crosswise, or at a considerable angle to the adjacent veneers. These layers are temporarily fastened in place by tacks, tape, or staples until the adhesive bond is cured. An inflatable rubber mattress A is laid over the outer veneer, and above this a sturdy semi-cylindrical steel shell B is placed, which is firmly bolted to the base E. This rubber mattress or closed bag is flexible rather than extensible. It is inflated through D with steam, hot water, or compressed air, or a combination of these fluid-pressure mediums. The fluid pressure forces the veneer layers together and against the mould at every point and holds them in that position until the adhesive bond is completed. It is necessary that the veneer strips be properly tapered before assembly, so that all ends and edges fit closely together.

The cross section at the lower left of Fig. 3 shows the equipment necessary to produce the same plywood shape when using an autoclave or cooker comprising a large cylindrical tank with an end door that can be sealed tightly. Here a convex mould F (similar to C mentioned), with the wrapped layers of veneer temporarily fastened in place, is placed inside the open-mouthed rubber bag G, whereas in the first instance the mould and plywood were outside the bag. Any air within the bag, either initially there or caused by subsequent leakage, is exhausted through the vent H. The mould F and its enveloping bag G on the transfer car K is placed in the autoclave T, continuing the vacuum or vent connection H to the outside of the autoclave. Steam, hot water, or compressed air is utilised to produce fluid pressure inside of the autoclave and against the rubber. This applies omnidirectional pressure of equal intensity over the entire curved plywood surface. Care must be exercised to avoid any air pockets in the vacuum area, which often requires grooves in the mould or perforated non-collapsible tubes to ventilate otherwise inaccessible spots. A ventilating pad should be located at the vent connection to prevent premature sealing at this point.

There is little difference between these two pressure application methods, as the intensity of pressure may be regulated equally well in either. In both cases the pressure is applied on the outside or convex side of the curved plywood. However, the amount of vacuum pressure is additional to the positive pressure above atmosphere. The autoclave equipment, with transfer car, results in somewhat more convenient operations.

The third method, shown in the lower-right cross section of Fig. 3, requires a thin metal mould L, the contour of which is braced by frequent cross frames N, which, in turn, are bolted to the platform of the transfer car R. In this case the required amount of rubber M is reduced to approximately one-half, since the air-tight metal sheet L serves as the other half of the vacuum enclosure. This single layer of rubber M, in the form of a blanket, is folded over and tightly clamped at all ends and edges to the thin metal face L of the mould. The vacuum connection P functions as has just been described, and air pockets must be similarly avoided.

A variant in this third method, not illustrated, is a plywood mould ¼in. to 1in. thick, which serves similarly as half of the bag. Heat penetration through this moderately thin wood is slower than through thin metal, but far more rapid than in the case of solid wood moulds.

In contrasting this third method with the two preceding ones, it is to be noted that the mould is concave rather than convex, thus giving the outer or convex side of the curved plywood a smooth streamlined surface, which is a distinct advantage in either aircraft or watercraft. It is also evident that the heat of the autoclave fluid medium is applied to both sides of the plywood, *i.e.*, through the rubber and through the thin metal. This permits shorter curing cycles for the adhesive, since there is not only the double application of heat, but also there is no heavy thick mould to retard the rapid penetration of heat into the plywood.

VENEER *versus* TWO-PLY LAYERS IN MOULDING

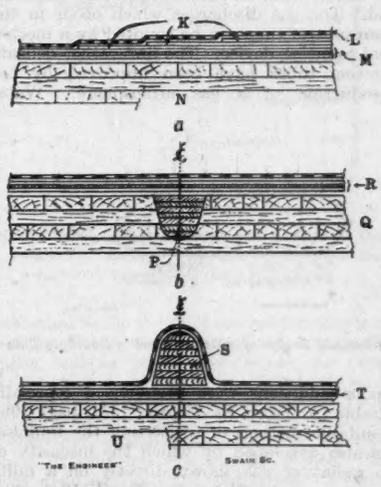
While the larger proportion of moulded plywood is made directly from single layers of veneer, there are instances where better results can be obtained from thin two-ply layers, bonded together flat. Constructions where single layers tend to split easily are examples. Another case is a boat hull, to be made by any of the methods shown in Fig. 3. Here a large sheet of two-ply layers can be used, which will obviate the necessity of handling and fastening many narrow pieces of single ply. Deep gores or vees are cut in the ends of these large sheets of two-ply layers, so that the edges of the cut-outs fit accurately when laid over the mould. Two or three sheets of two-ply layers are used, and the cut-outs properly staggered for strength.

EFFECTIVE *versus* INEFFECTIVE PRESSURE

One factor, which must be given due consideration in any of these fluid-pressure applications, is the inherent resistance of the wood layers to bending, twisting, or curving. It is a general rule of plywood moulding that the radius of curvature should not be less than approximately seventy-five times the thickness of the individual layers of veneer; hence the veneer thickness becomes an important design factor. A simple illustration of this resistance of wood to bending into curves is shown in Fig. 4. In this case, with a known total pressure at C, such as 60 lb. per square inch, an appreciable portion of this pressure may be neutralised by the stiffness of the wood or its natural resistance to bending, as at A and B. Assuming that it requires 10 lb. of pressure to hold the veneer layers snugly against the mould at A and B, then one-sixth of the total pressure at C is ineffective when applied at A and B, leaving 50 lb. of "net effective" pressure at the ends of the veneer layers. While this example is a relatively simple one, there are numerous more complex situations, where the ratio of ineffective pressure to net effective pressure may be distinctly greater. Adequate allowances must always be made for this factor of ineffective pressure in forcing flat wood sheets or strips into curved layers.

VARIABLE THICKNESSES

It was pointed out earlier in this paper that flexibly moulded plywood can be made in assemblies of varying thicknesses, and bonded together in one operation. Several examples are shown in Fig. 5. The upper sketch shows



a, Overlayers of veneer for reinforcing.
b, Stiffening rings of laminated wood recessed in mould.
c, Stiffening rings on bag side of plywood.

FIG. 5—*Variable Thicknesses in Moulded Plywood*

the overlaying of extra layers of veneer, which may be done on the bag side of the plywood, as shown, or on the mould side, by providing suitable recesses therein. This might occur where reinforcement is needed, as at the edge of a hand hole, a door frame, or where extra strength is needed inside the leading edge of the wing near the fuselage. The centre sketch, Fig. 5, shows a ring or aileron, prelaminated from parallel layers to the proper shape and recessed in the mould. Accurate dimensioning is imperative to keep the gluable surface of the ring exactly flush with the mould. If it is less than flush, the joint will be poor, and if it is too high, a ridge will show on the outside of the plywood. A more efficient method of attaching the rings or ailerons is shown in the lower sketch of Fig. 5, where the additional member is on the bag side rather than recessed in the mould. These variable-thickness constructions can be adapted to the three major types of technique previously outlined in Fig. 3.

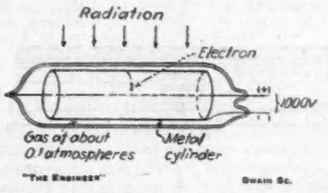
(*To be continued*)

DEVELOPMENT WORK AT DURBAN.—With an allocation of more than £5,000,000, to be spent on Natal's railway and harbour development works during the current financial year, over £900,000 will represent Durban's share, mostly on harbour improvements. The long-neglected Salisbury Island in the Durban Bay is to be "improved" to an amount of £373,156 for purposes of national importance during and after the war. A further £196,155, out of the estimated total of £2,164,680, has been allocated for the deep-water berth scheme, on which £1,593,662 has already been spent.

X-Ray Counting Tubes*

It has been known for many years that there are three ways of proving the presence of X-rays or gamma rays—by photography, sensitised fluorescent screens, and by Geiger-Mueller tubes. The higher sensitivity toward radiation of the Geiger-Mueller counting tube permits quantitative intensity measurements. Thus accurate wall thickness determinations are entirely feasible where film or screen testing would show merely local differences. Also the counting tube can work automatically, eliminating the human element in testing.

Some possible applications for the improved Geiger-Mueller counting tube in industrial testing are given in a German journal, *TZ für Praktische Metallbearbeitung*, August, 1942. The principle of the Geiger-Mueller tube, as designed in 1928, is shown by the sketch. A brass cylinder acts as cathode while a wire is arranged in its centre and serves as anode. These electrodes are enclosed in a glass filled with gas at about 0·1 atmospheric pressure. If a radiation rich in energy impinges upon the metal cylinder, electrons are released, travel to the anode wire, and discharge their electrical load. The gas discharges which occur in the mean unit of time can be counted by a mechanical counting device. The first rather delicate counting tubes have been improved by the introduction of a gas atmosphere. Water



Schematic Design of a Geiger-Mueller Counting Tube

vapour additions were pronounced especially suitable (A. Trost, *Zs. Physik*, 1937, page 399). A suitable method of registering the impulses was also developed by which the intensity of the radiation was shown directly on a milli-ampere meter (A. Trost, *Zs. Physik*, 1941, page 257). The sensitivity of the apparatus can be adjusted within wide limits to all practical radiation intensities. High intensities permit accurate and rapid determination, lower radiation intensities need correspondingly longer measuring periods. The radiation intensity is either read off the milli-ampere meter or recorded automatically.

Practical experience has shown that the counting tube and the film of fluorescent screen complement each other. The demarcation of the proper sphere of these various techniques depends largely on the size of the defects to be investigated. A film offers a plurality of qualitative local measurements and therefore small defects, such as cracks, pores, or slag lines, can be found easily. The counting tube, on the other hand, reproduces only one measured value which is in terms of numbers the mean radiation intensity across the whole field, given by the size of the counting tube or by the counting tube diaphragm opening. Defects extending across the whole field can, of course, be measured very accurately in a quantitative manner, but those which are small in comparison to the field naturally have only a limited influence upon the mean radiation value and are therefore registered either only to a limited extent or not at all. Generally, the field should not be smaller than 1 square centimetre to make the investigation of large areas economically possible. This means that film and fluorescent screen remain important as far as the investigation of small defects is concerned. But the counting tube is well suited for the investigation of defects which extend over large areas, such as differences in wall strength, corrosion phenomena, inclusions, porous areas, and heterogeneities.

Measurement of the wall strength of gas cylinders, pressure vessels, &c., in which mechanical measuring devices cannot be used, is greatly facilitated by this new testing method. The gas cylinder is placed upon a special mounting which permits the helical advance of the cylinder between counting tube and X-ray tube. Here the counting tube is inserted through the neck of the cylinder into the interior of the tube, the X-ray tube being placed as close as possible to the container wall and the radiation intensity being measured while the cylinder travels slowly past the test set-up. Any variations in thickness will reflect in the curve which is drawn from the current strength. The milli-ampere meter can be calibrated against sheets of known thickness and against X-ray tubes of known potential. Steel thicknesses up to about 2in. can be measured with an accuracy of 0·5 per cent., using a measuring arc of 2 square centimetres and a measuring time of one-tenth of a second. Percentage accuracy is largely independent of wall thickness, but when greater than 2in., the measured area must either be decreased or the time of measuring increased to retain accuracy. Using an X-ray tube emitting soft radiation and specially adapted counting tubes, lead, tin, copper, brass, or steel foils of only 0·0004in. thickness can be measured with an accuracy of 1 per cent. Even aluminium foils of 0·004in. thickness can be measured to an accuracy of 2·5 per cent. Lower limits are given by the window of the X-ray tube available and by the counting tubes.

* From *Iron Age*, June 10th, 1943.

High-Frequency Heating of Non-Metallic Materials*

Wood and other non-metallic materials can be electrically heated quickly and uniformly by a method recently adapted for plywood aircraft. To attain precise temperature control metals have long been heated by an electric current or by inducing current in them by an alternating electric field supplied by a coil surrounding the metal. Current can also be pushed through "non-conducting" materials, but economic operation requires use of a high-frequency current, one changing direction millions of times per second. Such heating is not competitive with steam heat, but it is rapid and easily controlled and speeds production cycles markedly. This high-frequency heating promises to become a major technique in difficult heating problems, both now and after the war.

High-frequency heating has been used medically for some time in diathermy treatment of various disorders by raising the body temperature locally. The industrial application of the physician's "diathermy" dates from 1936, when it was applied to the drying of tobacco while still in the hogshead. The present intensified interest stems largely from the participation of the furniture industry in the plywood aeroplane and glider programme. High-frequency heating enjoys the great advantage of having the heat produced directly in the material itself, and as rapidly as desired. Normal barriers to heat flow are not encountered, and the release of heat is uniform throughout the material, thus eliminating undesirable temperature differences.

The heat is produced by distortion of the molecules of the materials by the rapidly changing electrical field. To produce an appreciable effect the field must change rapidly, millions of times per second, which is far beyond the range of mechanical means of generating alternating currents. Such currents are obtained therefore from a high-frequency vacuum tube system, similar to a radio transmitter, but usually more powerful. The heating units employed are quite compact and in the smaller sizes are housed in a single cabinet containing all necessary tubes, transformers, and condensers. With the exception of cooling fans and some small control motors, there are no moving parts. They are built in heat output capacities from 500 watts to 300 kilowatts, and since the average overall efficiency of power conversion is approximately 50 per cent., the equipment consumes about twice as much power as it releases as heat.

Bonding together of thin wood sheets with synthetic resin glue to form plywood is particularly adaptable to high-frequency heating, because of the plywood's poor thermal conductivity and of the need for rapid and uniform heating. Structural beams, propellers, wing and fuselage parts may all be made by the process and the improvement over the older methods is remarkable. Plywood is formed in large presses, which in making some types have been steam heated to set the glue. High-frequency heating is at present applied to existing press equipment by inserting a metal sheet between two stacks of wooden sheets in the press. The metal sheet is connected to the power source and the other terminal to the press body so that an electric field is set up between the metal sheet and the press, and through the wood, thus heating the wood. The press compresses and within a few minutes the work is finished. High-frequency heating is much faster than steam heating, and is indispensable for thick sheets. It also permits the use of glues which set at unusually high temperatures. Later, when new press equipment can be had, it will permit use of cheaper presses, especially adapted to high-frequency heating.

Aside from laminated products the high-frequency heating method has been successfully tried on resin-binding of ground cork to form thick slabs. Cellulose, rubber, rayon, ceramics, plastics, textiles, and other non-metallic solids and liquids can be heated rapidly, accurately, and uniformly. It has been used particularly in preheating plastic material just before moulding.

In any particular application, high-frequency heating requires a considerable amount of development work, since existing equipment, such as presses, vats, ovens, &c., was not designed for the purpose. Appropriate portions of the equipment must be insulated, thought must be given to obtaining a uniform field through the material to be heated, and operators must be protected against the high-frequency current, which will burn but not shock.

Where ordinary methods of heat transfer can be applied, this electrical process will not compete, for its efficiency of power usage is little over 50 per cent., and fuel is basically much cheaper than electricity. But where low-heat conductivity presents a serious problem, and where operator and machine time is more important than power cost, the method deserves fullest consideration.

* From the *Industrial Bulletin* of Arthur D. Little, Inc., June, 1943.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

SPRING WIRE

B.S./STA. 1, 3, and 4. These three specifications for spring wire form part of the S.T.A. Series, the special series of specifications prepared to co-ordinate the requirements of the Ministry of Supply and the Admiralty. The three specifications cover respectively special first quality hard drawn, high quality hard drawn, standard quality hard drawn. The specifications give the chemical composition and tensile strength of different gauges of wire and torsion and wrapping tests are also specified. Additional tests are included for the better qualities, such as deep etch and the decarburisation tests. Price 6d. each.

UNIVERSAL DECIMAL CLASSIFICATION

No. 1000, Vol. II, Part 2. We are informed that the English edition of the Chemistry Section (Class 54) of the Universal Decimal Classification is now available as B.S. 1000, Vol. II, Part 2, price 10s. net. Class 621.3, Electrical Engineering, is in preparation and is expected to be available within a few weeks.

Steering Experiments*

By R. W. L. GAWN,† R.C.N.C., Member of Council

(*Continued from page 118, August 6th*)

§ 6. RUDDER TORQUE

CURVES of rudder torque deduced from experiments on a quadruple-screw warship model with single balanced rudder on the middle line are shown in Fig. 12 for full speed ahead and full speed astern respectively. Some models are tested at slow as well as full speed ahead,

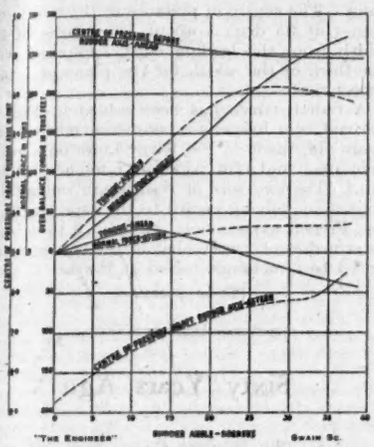


FIG. 12—*Curves of Normal Force, Torque, and Centre of Pressure*

having in mind provision for auxiliary steering at low speeds, as well as power steering at full speed. In most models the torque varies approximately as the square of the speed, but is subject to critical variations with rudder angle. At small and moderate angles the rudder torque in ahead motion increases progressively with increase of angle, the centre of pressure being before the axis, so that the rudder is overbalanced and drives the steering gear. The torque is reversed at 23½ deg., and is underbalanced at greater angles. Although the curve varies in a gradual way generally, there is an abrupt knuckle at about 20 deg. to 25 deg., with some models, and experiments have then to be made at closely spaced angular intervals in this region in order that the character of the curve may be well determined. Generally speaking, the effect of propeller race on rudder torque is small for the type of ship here considered, both for ahead and astern motion. There is a steady and progressive increase in astern torque from zero rudder angle up to about 25 deg. to 30 deg., the torque then remaining fairly constant or even declining slightly with further increase of angle. In considering the application of these results to the ship there seems no reason to apprehend any substantial scale effect akin, say, to skin friction correction, particularly as the tests are usually carried out on a fairly large model. The method of experiment is, however, not fully representative, since the conditions simulate approximately those obtaining on the ship at the instant when the rudder is fully over, and before the ship has turned off the initial course. Since the response of the ship to small rudder angles is comparatively slow, the difference in conditions may not be important, but at larger rudder angles they can only be regarded as representative of the instantaneous torque. Further, when the ship is steadily turning under full rudder angle, the relative flow in the neighbourhood of the rudder may well differ significantly from that of the controlled model. When the ship is going astern, however, with rudder over, the rate of turning is comparatively slow and the conditions of the model experiments are therefore more realistic and may well correspond sufficiently with those of the ship. This is important because in the case of a balanced rudder, although the speed required for manœuvring astern is appreciably less than for full speed ahead, the maximum rudder torque is much greater than in ahead motion. Therefore one may reasonably expect to take the model results astern without reserve as representing the requirements of hydrodynamic torque for the ship steering gear. Although from the reasoning above the ahead torque obtained in the controlled model experiments may not necessarily afford more than a conventional comparison with rudders torque measured on the steering trials of warships, it is generally found that there is a fairly good agreement. Ship circle trial results indicate that the drift angle at the rudder positions of a ship of the type considered in this paragraph may be as much as 20 deg. at the full rudder angle of 35 deg. It cannot be assumed that the drift angle at the rudder necessarily represents the correction to the rudder angle to obtain the effective rudder angle, but it is clear from the character of the rudder torque curve that the effective angle of the rudder is in the region of that corresponding to maximum overbalance torque in Fig. 12.

As an illustration of the extent to which the model results are borne out in practice, curves are shown in Fig. 13 of the rudder torques on three different vessels of one class of quadruple-screw warship with middle-line balance rudder. At full speed ahead the maximum underbalance torque deduced from experiments on a model of the class is 100 tons-feet at rudder angle of 28½ deg., compared with a maximum underbalance torque in the three ships concerned ranging from 130 to 75 tons-feet between 31½ deg. and 35 deg. Thus the model results

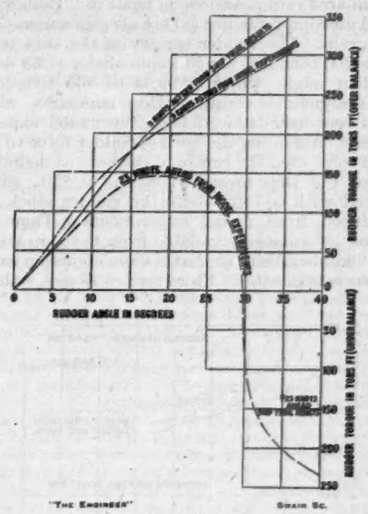


FIG. 14—*Rudder Torque Deduced from Steering Trials of H.M.S. "Rodney" Compared with Torque Deduced from Model Experiments (see § 6 of Paper)*

overestimate the overbalance rudder torque up to about 30 deg., and underestimate it at greater angles, and, as would be expected, the maximum torque occurs at a smaller rudder angle than in the ship. The astern rudder torque curves of the ships and of the model are similar in character, but the results deduced from the model experiments are slightly greater than those deduced from the ship trials. Bearing in mind that the astern speed is not measured with the same accuracy in the ship trials as in the model experiments and that the arrangements for measuring torque in the ship deduced from ram pressures are in the nature of the case less sensitive and accurate, particularly as correction for the rudder stock friction is involved, it is concluded that the model results can be used to determine balance of the rudder and the power of the steering gear with a fair measure of confidence for this class of ship.

Rudder torque measurements on H.M.S.

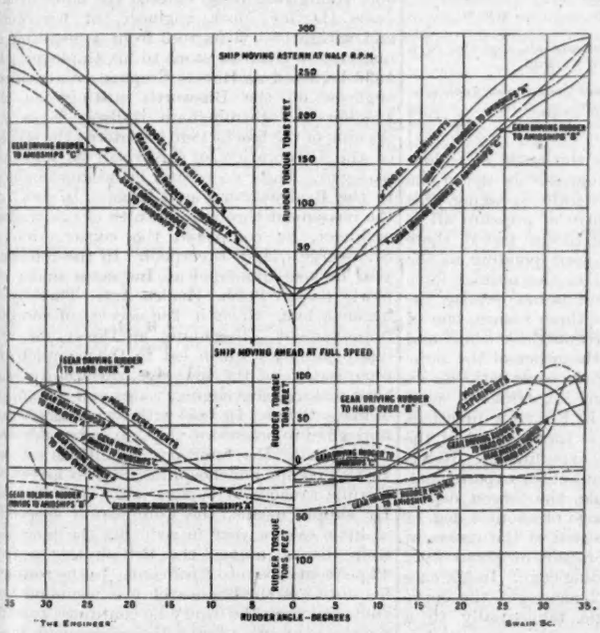


FIG. 13—*Curves of Rudder Torques on Ship and Model*

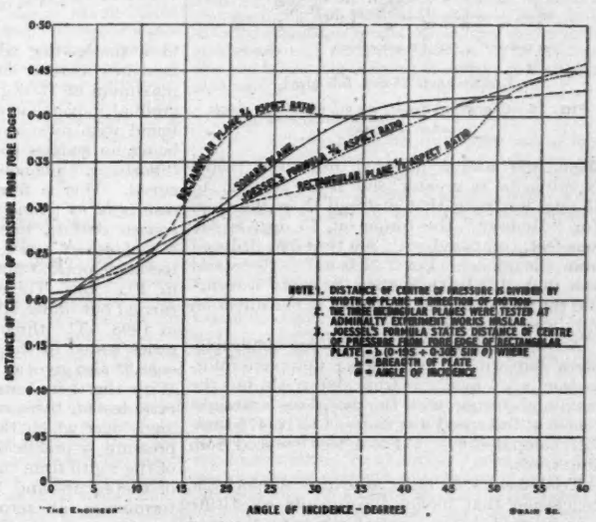
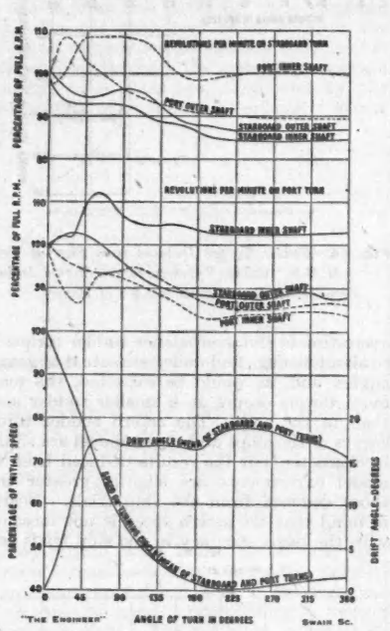


FIG. 15—*Curves of Centre of Pressure of Planes*

* Institution of Naval Architects, April 15th.—Slightly abridged.

† Superintendent, Admiralty Experiment Works, Haslar.

"Nelson" were included in reference (8)* in the bibliography, together with results deduced from model tests qualified by an estimate of the effect of the modifications in shape of the ship rudder as compared with that of the model rudder as tested. In view of the fairly complete information available from the ship trials, it was arranged to carry out experiments on a model of the ship and "as fitted" rudder at the displacement and speed of trial. Curves of rudder torque deduced from the model results are shown in Fig. 14. Rudder torques from the estimated ram pressures on trials of "Rodney" and given in reference (8) are also shown on this diagram. The rudder torque on the ship trial was 200 tons-feet for 23 knots ahead at 35 deg. rudder angle, which reduces to 135 tons-feet hydrodynamic torque. This compares with 200 tons-feet deduced from the model experiments. Assuming the normal rudder force to be 255 tons, then the centre of pressure as deduced from the ship measurements is 0·53ft. compared with 0·78ft. abaft the rudder stock as deduced from model experiments. There is more information available from the ship trials at 9 knots astern, so that a more complete comparison is possible. From zero to 15 deg. rudder



Rudder angle 35 deg. full speed

FIG. 16—*Change of Speed, r.p.m., and Drift Angle when Turning*

angle, the torque deduced from the model experiments is greater and from 15 deg. to 35 deg. less than that deduced from the ship. For "Rodney" the torque at 35 deg. is 345 tons-feet, compared with 300 tons-feet deduced from the model. For "Nelson" "the speed was undoubtedly less than 9 knots astern," and the rudder torque measured in one direction only was 297 tons-feet.

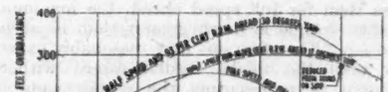
Another comparison is for a large quadruple-screw ship with twin rudders. Complete information is not available from ship trials, but the maximum torque with the model on a straight course at full speed was deduced to be 475 tons-feet, compared with 474 tons-feet deduced from ship trials.

Trial results of other warships support the conclusion that model experiments constitute a useful guide to the torque likely to be obtained on the steering trials of ships. It is reasonable to anticipate that when further information is available to permit of a statistical analysis on a sufficiently large number of ships to reduce the importance of errors in the records of individual ships, that a close approach may be obtained to the correction factor, if any, to be applied to the model results in passing to the ship.

An interesting experiment carried out in connection with one design was with the model on a straight course as above, but with speed of model and revolutions of propellers reduced and model held at a steady yaw to correspond to the conditions recorded on the ship circle trials, after turning through a sufficiently large angle for reasonably steady conditions to be established. The variations in conditions on the turning circle for this particular ship are indicated by the curves in Fig. 16, showing the change of speed, revolutions per minute, and drift angle amidships with angle of turn. The rudder torque curves deduced from the model experiments are shown in Fig. 17, for the ahead condition on a straight course at full speed, and for reduced speed ahead with drift angle of 17 deg. and propeller revolutions per minute reduced to 93 per cent. to accord with the ship conditions on the steady portion of the turning path. It is seen that with the model in the yawed condition the comparison with the ship torque is fairly close at 35 deg. rudder angle. With the model on the straight course the comparison between the maximum torque deduced from the model experiment and that on the ship trials can only be described as approximate, the difference amounting to 15 per cent. This case is rather a keen test of model and ship comparisons, in view of the proximity of centre of pressure to rudder stock.

§ 7. Centre of Pressure

Fig. 12 indicates the variation of position of centre of pressure with angle of rudder, and shows that the centre of pressure moves aft



Results deduced from experiments on a model of a quadruple-screw warship

FIG. 17—*Variation of Rudder Torque with Angle of Yaw or Drift Angle*

from the leading edge as the angle of rudder increases more or less progressively up to the maximum of 35 deg. Generally speaking, this gradual movement of centre of pressure aft is found with most types of rudder tested, there being no sudden change corresponding to the "burbling" phenomenon in the normal force curve. This is fairly well borne out by the results of experiments on three planes, one of square outline, one of rectangle outline and 2 to 1 aspect ratio, and the other of the same rectangle outline but 1 to 2 aspect ratio shown in Fig. 15. These plane experiments were carried out under Mr. R. E. Froude's directions in 1908. The three planes formed part of the series tested in the force experiments. Reference 9* also gives an account of the experiments. With the 2 to 1 rectangle, the largest aspect ratio tested, there is a range of about 5 deg. of angle over which the position of the centre of pressure is practically constant at about 0·22 of the width from the leading edge. In the case of the square and 1 to 2 rectangle, the curve terminates at zero angle tangentially to a constant ordinate line, but with a more or less uniform curvature. Theoretically the curves should approach the geometrical centre of the planes at 90 deg., although within the scope of the experiments they did not progress uniformly towards it, suggesting the far from surprising possibility that in the neighbourhood of 90 deg. the form of flow and consequential position of the centre of pressure are unstable and capricious. The difference in position of the centre of pressure for the three planes tested is comparatively small at angles from zero to about 12 deg. In so far as results for thin planes can be applied to rudders of finite thickness, it would appear that shape of outline has little effect at small angles. With increase of angle up to 35 deg., there is a substantial change in the position of centre of pressure, the tendency being for the centre to be located further aft the greater the aspect ratio of the plane, the difference being marked at 25 deg., although the square plane and rectangle of 2 to 1 aspect ratio from 30 deg. to 35 deg. show fair agreement. The centre of pressure of the two latter planes at 35 deg. is about four-tenths of the width from the leading edge, compared with one-third of the width for the plane of 1 to 2 aspect ratio.

A fourth curve has been added to Fig. 15 derived from Joessel's experiments, now seventy years old, made in the River Loire on a plane 16in. deep and 12in. wide (see references 4* and 10).† The two sets of results are remarkably consistent, having regard to the aspect ratio of the French experiments, namely, 3 to 4 being intermediate between that of the square plane, and 1 to 2 rectangle tested at Haslar.

(To be continued)

* "Some Steering Trial Results of H.M. Ships 'Nelson' and 'Rodney,'" Professor H. S. Pengelly, I.N.A., 1932.

* "Notes on Experiments made by Mr. R. E. Froude, F.R.S., on the Forces Operating on Plane and Curved Surfaces when Travelling at Various Speeds in Water," A. Mallock, F.R.S., R. & M., 16; A.C.A., 1909.

* "Normal Pressure on Thin Moving Plates," A. W. Johns, I.N.A., 1904.

† "Théorie du Navire," J. Polland and A. Dudebout, 1892.

Sixty Years Ago

Sir Robert Rawlinson

In our issue of August 17th, 1883, we noted with pleasure that Her Majesty had decided to confer a knighthood upon Mr. Robert Rawlinson, Chief Engineering Inspector to the Local Government Board. The honour was tardy. At the time of its reward, its recipient was in his seventy-third year, and could look back on a life well spent in the service of his fellows. Rawlinson was born at Bristol in 1810. His father was a general builder, and made his son successively learn the trades of bricklayer, mason, and carpenter. At the age of twenty-one, young Rawlinson entered the office of Mr. Jesse Hartley, dock engineer, at Liverpool, and within two years rose from a measurer of masonry to chief assistant to his employer. In 1836 he acted as Robert Stephenson's resident engineer on the Blisworth cuttings on the London and Birmingham Railway. On the opening of the line in 1840 he entered the service of the Corporation of Liverpool as assistant surveyor. Three years later he became engineer to the Bridgewater Canal Trust. In 1847 on the retirement through ill-health of the original architect, he completed the construction of St. George's Hall, Liverpool. In the following year he was appointed an Inspector under the newly passed Public Health Act. Thereby he began a long career in the service of sanitary improvement. Beginning at Dover, he held many inquiries which led to the complete reorganisation of the sewerage, surface drainage, road-making, scavenging, water and gas supply of many towns. In 1855 with two others he was appointed to proceed to the Crimea to take steps to improve the sanitary conditions of the British camps and hospitals, and to arrest the terrible ravages of typhus and other diseases. By simple means, the Commission succeeded in little over a year in reducing the mortality from disease among the British troops from 42 per cent. down to 2 per cent. In the course of his duties in the Crimea he was wounded by a shot, and from the injury he continued to suffer for the next two years. His subsequent career was devoted to many aspects of public health work. Notably during the cotton famine of 1865–66 he directed the carrying out of relief work by which the sanitary conditions of ninety-three Lancashire towns were improved. He also did much to prevent the pollution of rivers and as a Royal Commissioner to improve the sanitation of Dublin.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.

Production in Free China

In addition to beginning the manufacture of many new products, Free China in 1941 showed a marked increase in the output of general industrial articles, according to a survey made by the China Information Committee. The survey shows that up to early 1942 factories registered with the Ministry of Economic Affairs in the interior provinces numbered 1310 units. Many moved in from occupied or war areas, but a large number were newly established in the rear. Only a few existed before the war. Most of these private factories receive aid from the government. Eighty-seven of the 1310 units are mining and metallurgical works; 377 are machine and metal works; 44 are electrical equipment factories; and 273 consist of textile and clothing factories. A new feature in wartime China's industrialisation is the promotion of provincial enterprises. The provincial authorities have intensified their efforts in operating their own industries or in co-operating with the Central Government or private capital in joint undertakings. In Shensi, Kweichow, and Kiangsi provincial productive power has been highly developed. Units already in operation, under preparation, or being planned totalled 141 in nineteen provinces, according to the survey. Of these, eight are mining and metallurgical works, ten machine works, two electrical equipment factories. The National Resources Commission of the Ministry of Economic Affairs is the pivot in exploring the mineral resources of the country. The Commission operates the mines whose products directly concern war operations, such as petrol, antimony, tungsten, tin, and mercury. The provincial government works on all other mines, either independently or with the Central Government or private capital. As a contribution to the Allied cause, China is sending tungsten, mercury, antimony, and tin in considerable quantities to Allied countries. All the products are treated before shipment by plants maintained by the Commission. The Commission first took over the control of these "export minerals" in 1936 and has gradually extended its control. This centralisation has been effected in order to improve the methods of production and reduce the unit costs. Assaying offices for ascertaining the quality of the products are maintained. At present, three tungsten mines are being operated in Kiangsi by the Commission with modern equipment and modern methods of mining. In Kiangsi, Hunan, and Kwangsi, ore dredging units have improved the quality of tungsten ore. In the smelting of antimony the Commission has succeeded in bringing up the quality to a standard of more than 99·8 per cent. antimony and to less than 0·1 per cent. arsenic, which is much better than the present Chinese antimony regulus. Since the introduction of methods discovered by research experts of the Commission, tin produced in Kwangsi mines has an average metal content of 99·8 per cent., which compares favourably with the world standard of 99·75 per cent.

The Pig Iron Market

Compared with the heavy volume of business transacted at the end of the last quarter and the beginning of the present quarter, the amount of new business coming forward is comparatively light, and is likely to remain so until the beginning of October, when the fourth delivery period of the year opens. Allocations which were granted with some freedom at the end of June have been covered by most consumers, and the pig iron producers have a heavy tonnage of work in hand; in fact, the majority of the makers are in no position to accept new business until the fourth quarter. Some interference with production by the holidays was inevitable, but the necessity of repairing and overhauling plant and giving personnel a rest made it advisable to close down in some cases. The effects upon production, however, were mitigated as much as possible by staggering holidays in most districts over the midsummer period. The reduction of 1s. per ton in the price of blast-furnace coke from July 1st, 1943, has had little influence upon the market. The last price movement in coke prices was in July, 1942, when there was an increase of 6s. 6d. per ton to 44s. 6d. per ton. Although most foundries have covered their requirements for the third delivery period, the demand is sufficient immediately to absorb the output of pig iron. There is not much change to be noted in the hematite position. The production of this class of iron is increasing slowly, and deliveries to consumers are carefully rationed, and, where possible, users are urged to make use of substitutes. This position is likely to obtain until regular supplies of ore from North Africa are received. Consumers, however, are eagerly looking forward to an increased output which will relieve them of a number of difficulties that have been attendant upon the shortage of hematite pig iron. The production of refined iron has been pressed to the utmost, and is now on a considerable scale. The whole output, however, passes almost immediately into consumption. There are good supplies of high-phosphoric pig iron available, and in the Midlands the producers are reported to be holding stocks. The demand for this iron is steady, but for the past few weeks it has not shown the signs of expansion which were apparent previously. The light castings industry which normally absorbs large quantities of this pig iron is only partially employed, and although high-phosphoric pig iron is being used with success in many directions for which before the war it would have been considered unsuitable, the demand from these sources is not sufficient to make up for the loss of the trade from the light castings makers. There is a moderate demand for ferro-alloys, interest being chiefly in ferro-chromes and ferro-silicons. Supplies of tungsten powder are tight.

Scotland and the North

The Scottish iron and steel works, almost without exception, have particularly heavy order books. The demand for steel material from the shipyards seems to be ever-mounting, and few of the works have any spare capacity available for the third period. The demand from the firms employed in prefabrication, which was assuming considerable proportions, has decreased, as material required for this work is largely supplied now from stocks of imported American materials. The request for plates, however, shows no signs of relaxing, and large tonnages continue to pass to the shipyards. This demand comes within the high-priority category but large quantities are also required by other industries. The sheet makers are assured of full employment to the end of the current period, and many of the sheet mills are employed in producing light plates for the shipyards. The needs of the power plant producers are also a factor in the steel position. Producers of steel bars are kept constantly employed and the demand for the larger sizes is on a heavy scale. The bar iron makers are fairly busy, although the activity at these works is not nearly so great as at the steel mills. Most ironworks could easily accept a larger amount of business. The engineering industries in the Lancashire district are absorbing large tonnages of steel and their requirements of alloy steels are particularly noticeable. The demand has become more accentuated of late, and there is a tendency for delivery dates to increase. The call for plates is fully maintained and the producing works have enough work in hand to keep them busy for several months. The time required for delivery in this branch has increased considerably. On the other hand, delivery of structural steel, the lighter sizes of which are passing into consumption in considerable tonnages, is normal, and for the heavier sizes comparatively early dates can be arranged. There is a big volume of inquiry in the market for semi-finished steel, which is taxing the resources of the producing works. Steel production on the North-West Coast is fully maintained and practically the whole output passes immediately into consumption.

The North-East Coast and Yorkshire

There is no decline in the heavy demand for all kinds of steel. The resources of the makers are fully taxed to meet the demand, and the amount of new business coming forward is restricted by the ability of the producers to take fresh orders for delivery before the end of the third period. The re-rollers have been allocated large tonnages of billets, blooms, and sheet bars, and in a number of cases these quantities have been reinforced by supplies of imported materials. Altogether, the supplies reaching the re-rolling industry are considerable, but this does not relieve the re-rollers from the necessity of using any suitable material in the shape of shell discard steel, crops, &c. Consumers' requirements of plates show no signs of declining. Large as are the tonnages produced and passing into consumption, the demand more than keeps pace with the output. The shipbuilding industry has the first call upon plates, and recently has taken up large quantities of light plates rolled on the sheet mills. There is also a heavy demand for armour plate, whilst the volume of business in boiler and tank plates is well maintained, and in some cases works are receiving inquiries as to the possibility of deliveries being arranged during the first quarter of next year. Activity in the structural steel department is less, but, nevertheless, it is on a considerable scale. Heavy joists and sections are not required in the same quantities as the light descriptions, and many of the producing works are able to give the promise of fairly early delivery for the heavier sorts. The heavy demand for alloy steel is not so noticeable as in the earlier part of the year, but is sufficient to absorb immediately all the alloy steel produced; and efforts are being made to extend the production. The Yorkshire steel works are meeting with an insatiable demand for practically all kinds. There is a particularly heavy request for alloy steel, and although recently the production has been increased, steps are being taken further to increase the output.

The Midlands and South Wales

Pressure by consumers to secure deliveries has been fully maintained in the Midland iron and steel industry. This applies to practically every section of the trade. The re-rollers are fully engaged and are contributing big outputs to the production of small bars, small sections, strip, and sheets. The semis position is entirely satisfactory, and the supplies reaching the re-rolling mills are sufficient to relieve them of all anxiety on the score of supplies. The Control has now arranged for specific regular deliveries of billets, blooms, and sheet bars. These are largely from the production of home works, but in some cases this has been supplemented by imported American material. The satisfaction of the demand for plates is still a problem, but there have been no reports of the consuming industries having to put up with abnormal delays in deliveries. The demand for plates is principally for shipbuilding purposes, but locomotive builders, tank makers, and the heavy engineers are also taking large tonnages. Aircraft makers and other armaments manufacturers are calling for large supplies of alloy steel and the position of this department appears to be getting similar to that which existed a few months ago. Then production was increased, but whether this would be possible now remains to be seen. The demand for alloy steel appears to overtake production almost as quickly as it is increased. There is an active call for structural steel which appears to be gradually increasing, although it is concentrated chiefly upon the lighter sections. Heavy joists and sections are in comparatively poor demand, although recently the trade in this section appears to have become more active. All the South Wales iron and steel works are fully employed in the war effort. The demand for billets and sheet and tinplate bars keeps the producing works operating at capacity. The tinplate trade remains dull, but this is largely the result of necessary wartime regulations, which are likely to last as long as hostilities continue. The sheet works are not taking much new business as their production is booked up for a long time ahead. They also have a large amount of work in hand in manufacturing special-quality sheets. There is an active demand for special steels, largely from the armaments and munitions makers. The collieries also are taking big supplies of arches, roofing bars, rails, and props.

Iron and Steel Scrap

Following the holidays there was a brief revival in the demand for most kinds of iron and steel scrap, but subsequently the market became somewhat listless. Normally at this season of the year there is a tendency for rather quiet conditions to develop and this seems to be the case even in wartime. There is a strong request for good heavy mild steel scrap cut to furnace and foundry sizes, and as this is in short supply, consumers show some anxiety to cover their forward needs. This accentuates the tightness of the position. Bundled steel scrap and hydraulically compressed steel shearings are attracting more interest than for a long time, as they are being bought in fair quantities to add to the supply of heavy steel scrap. There is an abundant supply of mild steel turnings and most dealers find that the heavy qualities are not difficult to sell. Other descriptions are passing only slowly into consumption. There is a fairly good demand for mixed wrought iron and steel scrap for basic steel furnaces, and the activity in this section shows a tendency to increase. The good heavy material has an active demand, but the lighter kind is not so eagerly taken up. At the same time, the demand for the lighter sorts shows an improvement upon the volume of business passing only a short time ago. Compressed basic bundles are receiving some attention and heavy cast iron in large pieces and furnace sizes has been taken up recently in considerable quantities. Some consumers have found difficulty in covering their requirements. There is an active request for light cast iron scrap, and the parcels coming on the market pass quickly into consumption. A number of consumers of good cast iron machinery scrap who have delayed in covering their requirements for the present quarter are finding difficulty in obtaining sufficient quantities.

Notes and Memoranda

Rail and Road

L.N.E.R. Station Closing.—The London and North-Eastern Railway has announced that Tidal Basin Station, London, will be closed on and from August 15th for the duration of the war.

American Locomotive Order.—Ten steam articulated locomotives of the "Mallet" type have been ordered from the Lima Locomotive Works by the Chesapeake and Ohio Railway. These new engines will be used for the hauling of heavy freight traffic over the 80-mile section of the main line between Clifton Forge, Virginia, and Hinton.

Scarborough Train Accident.—On Tuesday morning, August 10th, there was an accident at Scarborough Station, L.N.E.R., when an incoming train from Hull crashed into the rear of a stationary train. The L.N.E.R., in its official statement, says that the first coach of the standing train was partially telescoped. Four passengers were killed and thirty injured.

L.M.S. Freight.—The average number of loaded wagons per freight train on the L.M.S. Railway has increased by five compared with pre-war. In addition, the average load of each wagon has increased. It is now 7·2 tons, compared with the pre-war average of 6·5 tons. It is officially stated that engine failures are remarkably few despite the extra burdens and the additional mileages they now have to cover without overhaul.

The Trans-Canada Highway.—According to a statement by the Ontario Highway Minister, the Trans-Canada Highway is now open from coast to coast. Traffic has started moving over the last stretch to be completed, which is the 153-mile length between Geraldton and Hearst in North-Western Ontario. This stretch was completed in November last, but no attempt was made to keep this link open through the winter.

The Micheline Electric Railcar.—A new type of electric railcar is reported by *The Railway Gazette* to have been introduced recently on the Paris suburban line between Pont Cardinet and Auteuil Boulogne. Its wheels are fitted with rubber tyres, and its four electric motors have a combined power of 194 H.P. Rapid acceleration enables the vehicle to attain its normal service speed within a few seconds. Its maximum speed is said to be 71 m.p.h. The railcar, officially styled "Micheline Z 23,271," is 124ft. 8in. long, and has accommodation for 256 passengers, of whom 120 stand.

The Institute of Transport.—At the recent annual general meeting of the Scottish Section of the Institute of Transport, Mr. R. J. M. Inglis, the divisional general manager of the L.N.E. Railway, read a paper on "Some Observations on Wartime Transport." He made a plea for post-war co-operation on the peace front similar to the co-operation between the transport services which was a salient fact on the war fronts. Much could be done, he said, to work out the future of transport by an accommodating goodwill on the part of the constituents of the industries. Speaking on the part played by the railways, Mr. Inglis referred to the 50 per cent. increase in traffic and the difficulties caused principally by the reorientation of industry and the movement of war equipment and personnel. Timber, which before the war came principally from Scandinavian and Canadian ports, was now home-produced, Scotland had dealt with 1,200,000 tons of timber on her railways. That meant loads of over twenty trains per day for every day of the year. Scottish potatoes had doubled in quantity, and over 440,000 tons had been carried by the railways, using 750 trains of fifty wagons each between October and March.

Air and Water

Great Lakes Fleet Additions.—Two large freighters for the transport of ore were delivered a few weeks ago by the Great Lakes Engineering Works. The United States Maritime Commission says that both vessels are 621ft. in length and that they are classified as single-deck bulk cargo ships of 14,500 tons capacity.

A Producer Gas Motorship.—Trials have recently been held of the Swedish motorship "Oaxen-Beta." *Shipbuilding and Shipping Record* states that this vessel, which is equipped with a two-stroke engine of 175 H.P. and is used as a tug and ice-breaker, is so far the largest Swedish ship to use producer gas. The apparatus consists of two parallel coupled Hesselman generators, each provided with a bunker containing 5 hectolitres of wood and a galvanised cooling and purifying system. To prevent different charges in the generators they are provided with automatic regulators at the entrance of the air inlet. The hourly consumption of wood is about 4 hectolitres, against a previous consumption of 30 kilos. of crude oil, and the cost of running is estimated at about Kr. 12 an hour.

Hydro-Electric Power in New Zealand.—Consideration is being given to the further development of the Waikaremoana hydro-electric project in New Zealand. The scheme includes the boring of a tunnel from a point 60ft. below the lake level through a narrow ridge which forms the lip of the lake and down to a power-house to be built approximately 800ft. above the Tuai generating plant.

Venezuela's New Airport.—The Ministry of Public Works of Venezuela has stated that a new airport is being built at San Antonio de Tachira on the frontier of Colombia, which will serve the growing domestic communications between Eastern and Western Venezuela and promote air travel between Venezuela and Colombia. San Antonio is about 12 miles west of the city of San Cristobal and 6 miles south-east of the Colombian border town of Cucuta.

Miscellanea

New Blast-Furnace.—A new blast-furnace with a capacity of 432,000 net tons a year was blown in during June at one of the plants of Bethlehem Steel Company. The new unit, which will produce about 1200 tons of pig iron every twenty-four hours, has a hearth diameter of 27ft. and is 105ft. high. Its total volume is 46,706 cubic feet.

A Radio-Telegraph Service.—A direct radio-telegraph service between Ecuador and the United States of America was put into operation in the early part of May. This service, which is operated in Ecuador by the Government Communications Department, also provides connections with all Latin America, excepting Lima, Peru.

American Peat Production.—Reports received from producers by the United States Bureau of Mines indicate that the output of peat in the United States in 1942 totalled 71,500 short tons, valued at 516,887 dollars—a substantial decline from 1941, when the production was 86,503 tons, valued at 657,556 dollars. The decline can be attributed largely to the cessation or curtailment of operations at many peat bogs because of inability to obtain the necessary labour to recover the peat. Commercial production in 1942 was reported by forty-one producers operating in seventeen States, compared with returns in 1941 from forty-nine producers in seventeen States. Some of the operators indicated on their returns that former employees are in the Armed Forces and that the plants will not reopen until after the war. Peat humus comprised 53 per cent. of the total production; reed or sedge peat, 31 per cent.; and peat moss and other, 16 per cent.

Fuel Economy in the Chemical Industry.—In connection with its fuel economy campaign, the Association of British Chemical Manufacturers, with the co-operation of the British Chemical Plant Manufacturers' Association, is organising a series of discussions on the practical aspects of the utilisation of fuel and power in chemical processes. The next discussion will be held at the College of Technology, Whitworth Street, Manchester, at 5 p.m., on Wednesday, August 25th, 1943. The subjects will be "Heating by Liquids" and "Heat Exchangers, including the Use of Effluents." Brief introductions by Mr. B. N. Reavell and Mr. H. F. Goodman respectively will be followed by discussions on personal practical experiences and questions will be welcomed. Non-members of the Association will be welcome, and should notify Mr. W. Murray (the Liverpool Borax Company, Ltd., Maxwell House, 6, St. Paul's Square, Liverpool, 3) not later than Saturday, August 21st, 1943, of their intention to attend.

A Container "Recovery" Service.—Over 600,000 fibre board cases are collected weekly for re-use in industry by the Container Recovery Service. This non-profit-making organisation, which is a specialised branch of S.P.D., Ltd., was set up two months after the outbreak of war in order to ensure the continued re-use of containers, which were obviously going to be in short supply as the war progressed. S.P.D., Ltd., is a transport firm, and its container recovery service has been extended to render assistance to a large number of other firms and a variety of trades. The service operates for over forty factories and deals with containers for over 100 lines, varying from margarine to soap and from floor polish to tins of syrup. On arrival at the depôt the cases are sorted and when a sufficient quantity has accumulated for any particular manufacturer it is dispatched to the factory concerned. Wood boxes, sacks, and iron drums also come under the collection scheme, which has proved valuable in prolonging the life of these articles and ensuring the minimum use of packing material in short supply and materially helping to save cargo space in merchant vessels bringing raw materials to this country. The latest figures show that 60,516,368 fibre board cases alone, as distinct from wood cases and other containers, have been recovered since the inception of the scheme.

Mineral Grinding.—Records on the grinding characteristics of coal and other minerals tested by the United States Bureau of Mines at one of its experiment stations have been compiled and contrasted in a recent report. Conducted at random over a long period to answer problems of the moment, the tests were made with the co-operation of the University of Alabama at the Southern Experiment Station of the Bureau of Mines at Tuscaloosa. The report records power consumption and size distribution data for the grinding of anthracite, bituminous, and boghead coals, cement clinker, chalcedony, chalcopyrite, chert, limestone, quartz, rutile, siderite, sphalerite, taconite, talc, topaz, and zircon. The minerals were segregated into four cleavage and fracture patterns, those with perfect cleavage, those with prominent cleavage, those with little or no cleavage and an uneven fracture, and those with conchoidal fracture. The tests disclosed that kaolin and mica could be ground to a finer size in the channel roller pulveriser used than in a steam jet grinder, and the efficiency of the pulveriser was at least as great as that of the steam or air jet grinder. The report adds that crushing and grinding resistances of a substance appear to be separate and unrelated properties, or, in other words, a substance hard to crush may be easy to grind.

Personal and Business

Mr. C. G. Miller has been appointed sales manager of Aveling-Barford, Ltd.

Mr. W. G. Swain has been appointed a director of Lancashire Dynamo and Crypto, Ltd.

Mr. Bernard Thomas has been elected President of the Staffordshire Iron and Steel Institute.

Mr. W. G. Bass, Mr. C. W. Bridgen, and Mr. W. C. Pycroft have been appointed directors of Ferranti, Ltd.

Mr. E. S. Shrapnell-Smith has become a director of the Eastwood group of brick and cement companies.

Mr. J. Bell and Mr. A. J. Chambers have been elected directors of Projectile and Engineering Company, Ltd.

Mr. C. J. O. Garrard has been appointed assistant manager and Mr. W. R. Cox chief consulting engineer in the switch department of the General Electric Company, Ltd.

The L.N.E.R. announces the following appointments:—Mr. J. Blair to be mechanical engineer (outdoor), Doncaster, in succession to the late Mr. C. H. M. Elwell; Mr. S. King, district docks machinery engineer, Hull, will succeed Mr. Blair; Mr. A. Moss to be assistant to engineer (signals), London; and Mr. L. Preston to be acting assistant to engineer (signals), Edinburgh.

David Brown and Sons (Huddersfield), Ltd., announce that Lord Brabazon, Sir Arthur Matthews, Sir Alexander Dunbar, and Mr. Walter Haydn Child have been elected directors of the company in addition to Mr. David Brown, Sir Ernest Roney, and Mr. W. Killingbeck. Lord Brabazon has been elected chairman and Mr. David Brown continues as managing director. These appointments have the approval of the Ministry of Production.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Marine Engineers

Tuesday, Aug. 24th.—85-88, The Minories, E.C.3. "Developments in Propeller Design and Manufacture for Merchant Ships," L. C. Burrill. 5.30 p.m.

Junior Institution of Engineers

Saturday, Aug. 21st.—Midland Section: Visit to the Birmingham City Transport repair works. 2.30 p.m.